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FINAL REPORT  
ON  
LAUNCHERS AND  
IMPROVED COMPONENTS  
FOR 4.5 IN. ROCKETS

TECHNICAL INFORMATION BULLETIN  
ORDNANCE RESEARCH CENTER  
ABERDEEN PROVING GROUND  
MARYLAND

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DIVISION 3, SECTION H

FINAL REPORT  
ON  
LAUNCHERS AND  
IMPROVED COMPONENTS  
FOR 4.5 IN. ROCKETS

Submitted by the Bell Telephone  
Laboratories, Inc. for the  
Western Electric Company, Inc.  
under Contract No. OEMsr-256

by *D. A. Dumas*  
Director of Apparatus Development

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Approved: Section H, Division 3

by *Elmer H. Hopkin*  
Assistant Scientific Officer

Approved for Distribution

O.S.R.D. No. 6156  
Copy No. 50

by *J. L. Hooda*  
Chief, Division 3

Prepared by:

Part 1 and 3 - J.M. Dietz *JMD*  
Part 2 - R.F. Mallina *RFM*  
Part 4, 5 & 7 - C.F. Spahn *CFS*  
Part 6 - J.M. Melick

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PREFACE

The work described in this report is pertinent to the project designated by the War Department Liaison Officer as OD-165, and to the project designated by the Navy Department Liaison Officer as NO-248. The testing of the components described was carried out at Indian Head, Md. by Section H under Contract OEMsr-273 with the George Washington University. When the laboratory work of Section H was transferred from Indian Head, Md. to Cumberland, Md. the testing was carried on by the Allegany Ballistics Laboratory which was operated by the George Washington University under the same contract. The testing of these components is described in the Allegany Ballistics Laboratory Reports (Improvement of Components for 4.5" Rocket MS O.S.R.D. No. 5777). This project is referred to in their files as W-40. Many of the components and much of the engineering was provided by the Budd Wheel Company under Contract OEMsr-968. The work they did is described in their Final Report (Miscellaneous Development of Rockets and Accessories O.S.R.D. No. 6152) and in their Final Report (Rocket Powder Traps O.S.R.D. No. 6147).

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## ABSTRACT

This report covers the development of launchers and improved components for the 4.5" rocket and is divided into Seven Parts (VII Parts).

## PART I

In the development of a light weight ground launcher for a 4.5" rocket several models were built and tested. The knowledge gained from these tests about the blast forces resulted in improvements in the strength and stability of succeeding models. A study of the forces involved showed that a low projector with long legs gave the best stability. Methods of utilizing component forces of the blast were studied and tested. It was found possible to construct projectors which were very light and which could be fired repeatedly from the same emplacement.

## PART II

A jungle launcher was designed with legs made of wood, a vertical column of plywood or plastic and a launching tube of plastic. The firing mechanism consists of two spools of wire that are soldered to the rocket and unwound after the launcher is set up. The weight of the complete outfit that the soldier must carry on his back is 62 pounds.

### PART III

There was also designed and constructed by the Bell Telephone Laboratories a rotating projector for the purpose of studying the effect of rotation of a rocket on its dispersion. The model was made in such a manner that the projector tube was rotated through pulleys and belt by a 1-1/2 h.p. induction motor. Provision was made for changing the pulleys so that different speeds of rotation could be obtained. The results of the tests were both interesting and valuable. They led to developments which greatly reduced dispersion of rockets.

### PART IV

The tail end of the 4-1/2" Army Rocket was redesigned for the purpose of coordinating the parts which affect the ignition system. The ignition system is closely associated with other parts of the rocket and rocket launcher. The redesign could not be restricted to the ignition system only, but had to be extended to the fin mechanism, the holding mechanism, the cowling, the fin retainer and fin protection. The effects of the tail end on the stability and drag of the rocket are shown by curves which were plotted from wind tunnel test data.

### PART V

An igniter was developed for use on the 4.5 inch rocket which may be inserted through the nozzle. It is attached to the closure cup which carries an electric plug. The igniter

is made in the form of a long envelope and is filled with suitable black powder with a squib centrally located. The thin envelope permits the insertion of the igniter between the powder sticks and the burster tube. Ignition takes place quickly throughout the length of the rocket. The ignition time is greatly reduced and much more uniform. All hangfires were eliminated by the use of this igniter. It was adopted by the Air Corps for use in the T-23 kit supplied in the field for forward firing from planes launched from zero length rails.

#### PART VI

Eighteen devices for holding rockets in the launching tube were designed. Models 1, 2, 3, 4 and 7 were suggested for use with contact rings attached to the fin flanges of the Eveready fin assembly. The other models were intended to provide a means of holding the rocket in the launchers other than the fin flange. The fin flange induced considerable air resistance and resulted in reduced ranges. Formerly the flange could not be eliminated as it was the only means available of holding the rocket in the launching tube. A schematic of the G.E. holding device which engages this fin flange is shown. Except for Model No. 8 which engages the front and rear end of the rocket, all of the other models hold the rocket by an angular groove in the motor.

PART VII

The pressure developed in a rocket increases with an increase in the ambient temperature and if a rocket is loaded for a cold climate and used in a hot climate without removing some of the propellant powder there will be danger of its bursting. Conversely, if it is loaded for use in a hot climate, there will not be sufficient powder for firing at low temperature. A regulating pressure device that would permit the use of a rocket in any climate was designed and developed by the Laboratories.



## PART I

LIGHTWEIGHT ROCKET PROJECTORSINTRODUCTION

In the early development of the 4-1/2 inch rocket, NDRC received requests from the Marine Corps for lightweight projectors which could be carried by planes and dropped with parachutes together with rounds of ammunition for use by paratroopers or which could be carried to shore from boats by soldiers. The Bell Telephone Laboratories were requested by Section H, NDRC to give this problem some thought. The project was assigned to Mr. R. F. Mallina. In order to gain knowledge concerning the blast forces from the rocket he built the first model of wood. On firing it was crushed by the blast. The next model was made from gas pipe with short legs. It was strong enough but was not stable. Each successive model was designed to eliminate any inadequacy which was made manifest on firing the preceding model. Studies were made of the forces involved and this knowledge was made use of in subsequent designs.

Description of ProjectorsProjector No. 1

The first projector was constructed of wood. The short launching tube could be elevated to any desired angle by means of coarse and fine adjustments. A certain amount of azimuth adjustment was also provided. The first round fired from this projector completely crushed it. This indicated

that the blast from the rocket was so severe that if it were to impinge on a broad surface the forces would be sufficient to demolish any structure made of wood.

Projector No. 2

Photograph No. 106174, Page 25 shows projector No. 2. It was made from gas pipe fittings. The legs were readily removable and were provided with flat gas pipe flanges. A small adjustment could be made in the height of each leg by a valve stem fitting. The short projector tube was mounted on an angle iron structure which was pivoted at the rear and provided with an elevating arm. Coarse adjustment in elevation was made by sliding the base of this elevating arm horizontally along a pipe provided for that purpose. Fine adjustment in elevation was made by a small crank which was threaded and attached to the flange which was used as a foot for this leg. Coarse azimuth adjustment was made by shifting the position of the projector. Small variations in azimuth were made by means of a worm screw, each end of which terminated in a valve handle. The first time this projector was fired it was demolished because the plastic launching tube was not strong enough to withstand the gas pressure. When it burst, the downward pressure was sufficient to crush the projector. It was later repaired and when used with a steel launching tube functioned satisfactorily except that it was highly unstable. It would rear up on the two hind legs and oft times would turn completely over. It was therefore decided

that a projector in order to be stable would have to have rather long legs and be built as low as possible.

### Projector No. 3

In the meantime however, projector No. 3, shown in Photograph No. 107212, Page 26, had already been designed. The legs were provided with spades which could be pressed into the ground. These were very effective in keeping the projector in position but the over turning moment was considerably worse than with Projector No. 2. The adjustments in elevation and azimuth of this projector were more condensed. They however, were not as satisfactory because it was found that loose play had a greater effect on the stability of the launching tube.

### Projector No. 4

The design of projector No. 4 had been started before projectors No. 2 and No. 3 had been tested. Since it had a base which was rather high, like projector No. 3 and would therefore, be highly unstable, it was never built.

### Projector No. 5

Projector No. 5, shown assembled and in carrying case in Fig. No. 7, Page 31, incorporated the low structure with long legs so that the line of thrust from the gas blast would be within the triangle formed by the points where the legs of the projector touch the ground. The elevating mechanism for this projector consisted of a rod which slides in a tube

provided with a clamp at one end. The projector could be elevated to any desired position and when the clamp was tightened, it would stay put. Fine adjustment was provided by means of a knurled handle having right and left hand threads. By rotating this knurled handle small adjustments in elevation could readily be made. Coarse azimuth adjustments were made in the same manner as with projector No. 2, that is, by bodily moving the entire projector. Fine adjustments were made by means of a screw and valve handle. These controls were all located so that while the gunner was looking through the sights, they could be adjusted (See Fig. 16, Page 37.)

To anchor the projector legs firmly to the ground, a spade was provided for each leg (See Fig. 1, Page 27). This feature which was incorporated in projector No. 3 was retained in all subsequent models. The front spade is driven into the ground at an angle of  $60^\circ$  with the horizontal and the two rear spades at an angle of  $90^\circ$ . In later models, spikes without the spade feature were found satisfactory. If in some instances it is difficult to drive the spades into the ground, the front leg is so constructed that it would be a very simple matter to weight the front leg down with a sandbag or a rock.

The three legs were inserted in this and all later models as shown in Fig. 4(d), Page 28. The legs were held

securely by means of a thumb screw 2 engaging in a depression 3. A pin 4, (Fig. 4(b), Page 28 ), engages in a slot 5 locating the leg axially as well as peripherally. Since it is not desirable to have a close fit between the legs and the sleeves into which the legs fit, special means were devised to make a rigid connection and yet provide an easy entrance for the legs into the supporting sleeves. A V-block arrangement as shown in Fig. 4(a) was used for that purpose. There are two forces which act on this system:  $F_1$ , a force imparted to the leg by the ground, and  $F_2$ , the weight of the projector. Actual V-blocks were not used in this model but the principle was the same, their place was taken by screws 9 and 10 in the leg sleeve 8 as shown in Figs. 4(c) and (d), Page 28 . This type of leg mounting has proved to be very satisfactory and inexpensive.

Figure 5, Page 29 , shows a simple type of breech mechanism that was developed for this projector. This mechanism consists of a hook which provides a forward as well as a backward stop for the rocket in the projector, a protection tape for the fins and two ignition wires with contact clips. Figure 5(a) shows the tape which is merely a strip of paper wrapped around the fins to hold them in place so that easy entrance into the projector tube is assured without injury to the fins. Figure 5(b) shows the paper torn off and the wire

clips connected to two terminal pins which provides the firing potential. This type of loading device is simple in construction and inexpensive, but it requires in addition to the loading operation the orientation of the fins, the tearing off of the tape, and the insertion of the contact clips.

In order to reduce the loading operation to its simplest form, that is, to the insertion of the rocket with no further manipulation, a plug was designed as shown in Fig. 6, Page 30. This plug has six functions: (i) it seals the opening of the venturi with a gasket 12, (ii) it presses the fins against the body of the projectile with a cardboard annulus 10, (iii) it provides a stop in the forward direction by butting against the projector tube 16, (iv) it provides a stop in the backward direction by engaging in a notch of the hook 2, (v) it provides two slip rings 14 and 15, and (vi) it provides a mounting for the squib cap 13. Contacts through the slip rings 14 and 15 are made by hooks 1 and 2 Fig. 6(b), Page 30, which are completely insulated from a cradle attachment 6 and 8 Fig. 6(c). The hooks 1 and 2 rotate about a pin 7 and by means of a torsion spring 4 and 5 supply a constant pressure to contact pins 3 assuring a positive connection with the slip rings. Wires from the squib 17 Fig. 6(a) are connected to slip rings 14 and 15. The solder joint is at eyelet 9. Several features of this breech mechanism have been retained in later models as will be seen and it is an alternate type of mechanism suggested for projector No. 7.

The carrying case measures 9 in. x 10 in. x 6 ft. About 1 min. is required to unpack and assemble the projector for use. The total weight of this projector including a 5-ft. fiber tube, spades and spikes is 80 lb. The case weighs 17 lbs.

### 3. Projector No. 5A

The next projector design was so similar to that of projector No. 5, Page 31, that the designation 5A, Page 32, was given to it rather than a new number in the series. It differed from projector No. 5 in the following details.

The firing tube was made of steel rather than fiber in this and all succeeding models.

A screw type adjustable center support was provided to increase the stiffness of the mount in the vertical direction Fig. 8, Page 32. In later designs the diameter of the vertical column was increased thus removing the necessity for this center support.

The screw threads for azimuth and elevation adjustment were covered by projecting sleeves (Fig. 8) to prevent the accumulation of sand and dirt in the threads. All later models have retained this feature.

The azimuth adjustment device in projector No. 5 was stationary. In projector No. 5A it rotates with the launching tube as in all subsequent models.

The fine azimuth adjuster for projector No. 5A was designed so that one turn of the control wheel was the equivalent

of 8 circular mils. The control wheel was provided with four notches equally spaced so that a quarter turn, that is, a 2 angular mils adjustment, could be readily obtained. This feature is retained in the latest model.

The distance between the horizontal pivots in projector No. 5A was increased to 6-5/8 in. to provide more rigidity of the launching tube. On projector No. 5 it had been 4-13/16 in.

The breech mechanism was equipped with the automatic contacting device that was described in discussing projector No. 5 and is shown in Fig. 9. The loading of projector No. 5A and the fine adjustment of azimuth and elevation is shown in Fig. 10, Page 33.

For paratroop use a cardboard tube was designed for packing projector No. 5A. The tube weighed 17 lb. including the two end plugs, two latches and two carrier handles. The end plugs were made of corrugated cardboard about 2 in. thick and were intended for absorbing the landing shock. The packing tube was 6 ft. 4 in. long and 10 in. in diameter. Complete with projector, three spades and three spikes, the package weighed 105 lbs. If dropped by parachute, three such packages bundled together in cloverleaf fashion would weigh 315 lbs. The jungle burden carrier as shown in Fig. 11, Page 34, weighs 320 lbs. and would also be dropped by parachute. A bracket made up of a short length of tubing having the same diameter as that of the legs of the projector would be securely fastened to the carrier. The basic unit of the projector with the legs removed could then be mounted on the carrier



by sliding the front leg sleeve onto the short tube bracket. The pin and thumb screw would secure it in place.

A new type of fin mounting was developed at this time Fig. 12, Page 35, in order to streamline as much as possible the structure to which the fins are pivoted. In this new design stationary fins that serve to improve the stability of the rocket in flight have been added to the folding fins. The new fin assembly consists essentially of three main elements: base tubing, stationary fins and folding fins. The base tube fits over the rocket nozzle and may be either welded, braced or riveted to the rocket body. Threads on the base tubing are used for screwing on the slip ring cap. This cap presses the annulus against the fin extension thereby providing a fin holding device. Since the annulus is larger than the inside diameter of the launching tube, it acts as a forward stop in loading. A backstop is provided by the contact levers shown in Fig. 9(a), Page 32.

Projector No. 5A and the breech mechanism shown in the photographs Page 32, were tested at the Indian Head Laboratory on June 16, 1943 and performed satisfactorily.

#### 4. Projector No. 6

Projector No. 6, shown on Page 36, was a modification of projector No. 5A that increased the stiffness about the azimuth axis. The diameter of the tubular column of the models preceding projector No. 6 was small in comparison with other structural parts. The torsional stiffness of a tubular column varies with the fourth power of its diameter. The increase in rigidity of

the new design was therefore considerable since the outside diameter of the vertical column in this model was 3 in. while in projector No. 5A it had been 1-3/4 in.

Another change which improved the stability of the projector was shifting the point of support of the launching tube closer to its center of gravity. The diameter of the legs was increased somewhat to balance the rest of the structure. Although the center foot was provided as in the previous model, it was found that this could be eliminated due to the improved rigidity of the projector.

In packing projector No. 5A in a 10-in. cardboard tube, it was necessary to disconnect the projector's elevation adjusters. This was not necessary in projector No. 6, Page 36, nor in the later model since the elevation angle can be changed from 0° to 90°.

A simplified method of connecting the ignition wire of the projectile to the projector is shown in Figs. 13, Page 36, and 14, Page 36. The ignition wire is stored in the plug 6 Fig. 14 which seals the rocket and also holds the control valve in position. In order to take the coiled wire 7 out of the plug 6, the paper disk 9 is pulled out by the tab 10. The bare ends of the wire 7 (11 and 12) are slightly soldered together by a joint 13 in order that the squib line will remain short-circuited until the rocket is inserted in the gun. Before connecting ends 11 and 12 to the terminals on the gun, Fig. 13, Page 36, they are first torn apart and then slipped under the wedge-shaped opening of the spring terminal.

The scrapping action of the wire against the sharp edges of the terminal insures a good contact.

Figure 15, Page 37, shows aximuth and elevation adjustments for projector No. 6 and the larger vertical column that was used in this model. Figure 16, Page 37, shows the projector set up for firing.

On August 19, 1943 projector No. 6 was tested at the Jet Propulsion Research Laboratory, Indian Head, Maryland and gave satisfactory performance. Revere 4-1/2-in. rockets were fired from the projector for the purpose of noting changes in elevation and aximuth of the mount with the results given in Table I.

Table I. Firing tests of projector No. 6 with Revere 4-1/2-in. rockets.

Round No.	Change in Azimuth (mil)	Change in Elevation (mil)	Rocket Lateral Deviation (mil)	Remarks
10911	0	0	+3	No pin in front leg
10912	+3	+1	+4	No pin in front leg
10913	0	+3	-15	No pin in front leg
10914	0	0	-38	Pin in front leg
10915	0	-3	+9	Motor parted at threads
10916	0	-6	-19	Trap failed

The change in azimuth was quite small. A slight adjustment in elevation was necessary when the pin was not in the front leg but the results of the one round when the pin was in, showed promise of making this adjustment less frequent. No further tests were made after the two motors failed, although the projector was undamaged.

#### 5. Projector No. 7

Projector No. 7, shown on Page 38, the latest model, is a low mount projector that incorporates the basic construction and controls of projector No. 6. The firing tube is 26 in. from the ground, representing a 10-in. reduction from the height of previous models.

A design feature new to this type of mount is the inclusion of an auxiliary frame Fig. 17, Page 38. This frame permits the firing tube to be raised so that the projectile may be inserted when the elevation setting is such that the resulting clearance between the rear of the firing tube and the ground is insufficient to load the projector in the conventional manner. The auxiliary frame is hinged directly to the vertical column. The firing tube is hinged to the auxiliary frame at one end and rests in a cradle bracket at the other end. Thus the projector may be loaded and fired without readjustment for elevation and azimuth.

The following parts have been redesigned for projector No. 7 as a result of actual field tests of model No. 6.

(1) The coarse azimuth control sleeve has been increased in thickness; the fine azimuth control arms which were formerly made of 1/2-in. pipe have been replaced with larger seamless steel tubing, and longer bearing surfaces have been provided.

(ii) The firing tube clamping strap is now assembled by spot welding, and the associated T bolts are made of one-piece steel.

(iii) The thumb screws for securing the legs to the vertical column have been replaced with wing bolts and are not removable.

Details of the design of projector No. 7 are shown in Fig. 18, Page 39, and the loading of the projector when set for high elevation is shown in Fig. 19, Page 40.

Projector No. 7 is lighter than model No. 6. The weights of various parts of the four last models are given in Table II.

Table II. Comparative weights of four models of the projector for the 4-1/2-in. rocket.

Part	Weight (lb)			
	Model 5	Model 5A	Model 6	Model 7
Firing tube	12.25	31.50	31.50	34.00*
Main Shaft assembly	18.25	24.25	25.50	28.00
Legs	30.00	22.50	34.00	32.50**
Entire projector	63.50	78.25	101.00	94.50
Carrying case	17	17	15	--

\*Firing tube and latch.

\*\*Three legs; front leg, 11.00 lb; each rear leg, 10.75 lb.

Vertical and lateral deflections produced by an applied force show the mount of model No. 7 to be quite rigid. A force-deflection diagram is shown in Fig. 20, Page 41.

### Theoretical Studies of Blast Forces from a Rocket as it Leaves the Launching Tube

1. For a simple launcher such as No. 6 or No. 7 Fig. 21, Page 42 shows by means of heavy lines a lightweight launcher. Equations are given showing the turning moment  $f_1$  about the line joining the point of contacts of the rear legs as a function of the blast force  $F_1$ , the height of the projector  $H$ , the distance from the turning axis to the center of gravity of the launcher  $L$ , the horizontal distance from the pillar post of the launcher to the line joining the points of contact of the rear legs, and the angle of elevation. The equations show that this moment may be reduced by keeping  $H$  small and  $L$  large. A slight reduction in the moment may be obtained by keeping the center of gravity,  $G$ , low. The launcher will be stable if the projection of the tube strikes the ground in front of the line  $e$ .

### 2. For a Launcher Provided with Holes in the Top of the Launcher Tube Near the Muzzle

It was suggested that by making holes in the top side of the launcher near the muzzle, that the reaction of the gases emerging from these holes would give a force which could be made to offset the force of the turning moment  $f_1$ . Computations however indicated that the holes would have to be quite large and these interfered with the free passage of the folding fins. There was a tendency for the folding fins to open up and catch in these holes so that this method of reducing the overturning moment was abandoned.

### 3. For a Launcher Provided with an Inclined Blast Shield

Fig. 22, Page 43, shows a launcher provided with a blast shield set at an angle so that a component of force is introduced which tends to offset the turning moment about the point e. The equations under this sketch show the conditions which must prevail in order to completely neutralize this turning moment. Projectors of this type were built and tested and found to be satisfactory. However, in order to obtain the downward component of force at the muzzle of the projector, a considerable rearward thrust was added. This, of course, necessitated making the structure of the launcher appreciably heavier and also made it necessary to provide anchor pins to keep the launcher from slipping with respect to the ground.

### 4. For a Launcher in Which the Launching Tube is Cut At an Angle at the Muzzle End

Fig. 23, Page 44, shows the theoretical equations for obtaining a balance of a launcher by cutting the muzzle end of the launching tube on a bias, the lip portion being down. As the rocket leaves the launching tube the gas pressure on this lip introduces a force in the opposite direction from the turning moment caused by the impingement of the gases on the launching structure. The equations show the conditions for completely neutralizing the turning moment. Launching tubes were tested in which the angle of the bias was varied progressively until the point was reached where this downward force was greater than the upward force due to the turning moment. This scheme

has the advantage of not increasing the cross-sectional area of the structure in the path of the blast.

#### CONCLUSIONS

It was found possible to design lightweight projectors which could be repeatedly fired without having to relay them after every round. Any or all of the foregoing methods may be made use of in achieving the desired results. The testing of these launchers was carried out at the Jet Propulsion Research Laboratories, Indian Head, Md. Engineers from the Bell Telephone Laboratories were present at most of these tests. While none of ~~these~~ projectors were used in service they were found, according to tests to be quite satisfactory.



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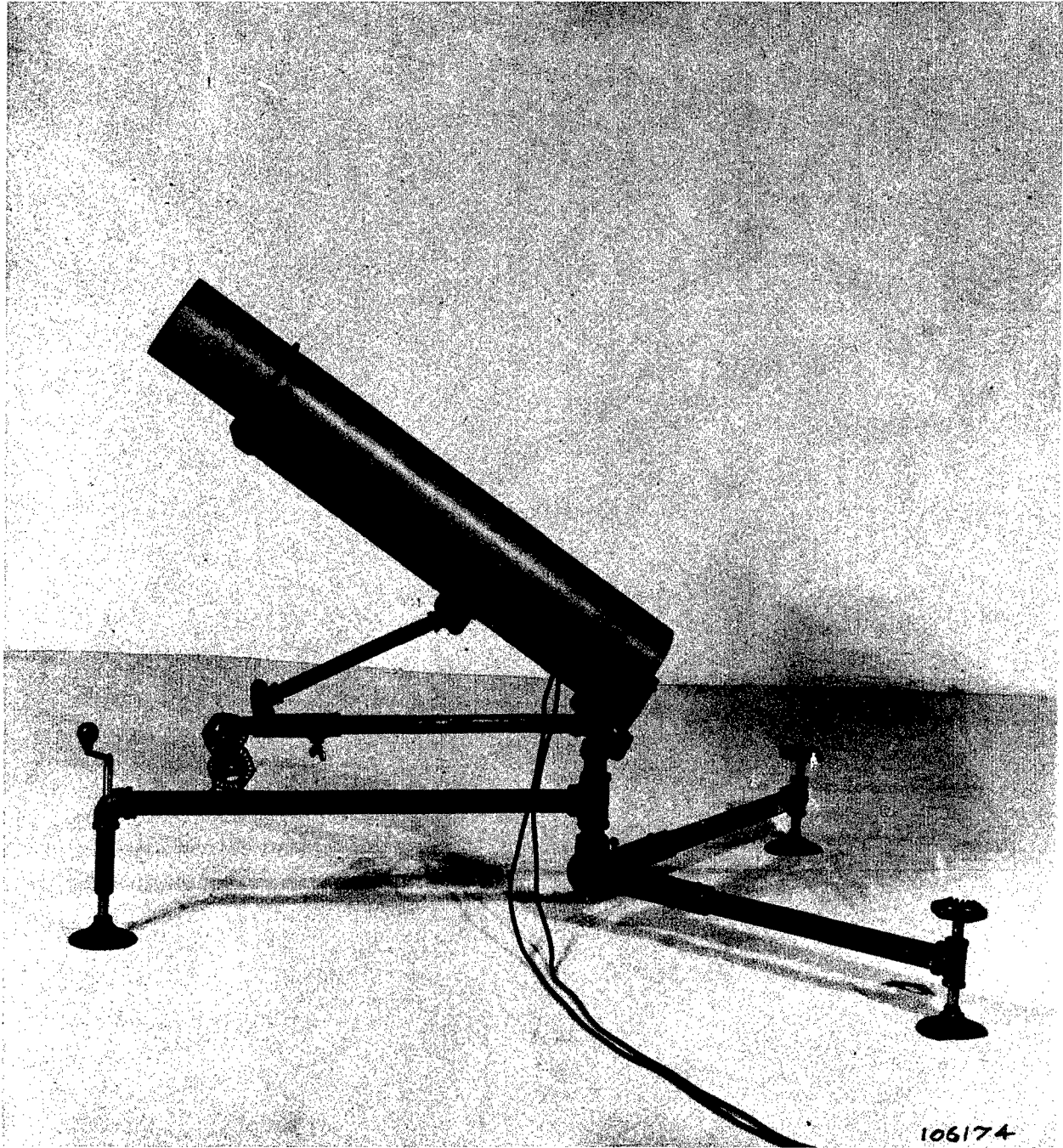
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February 14, 1944, Memo for File by J. M. Dietz on Rocket Projector Model No. 7.

April 5, 1944, Armor and Ordnance Memorandum No. A-89M (OSRD No. 3446) by R. F. Mallina and J. M. Dietz on Light Weight Rocket Projectors.



PROJECTOR NO. 2



107212

PROJECTOR NO. 3

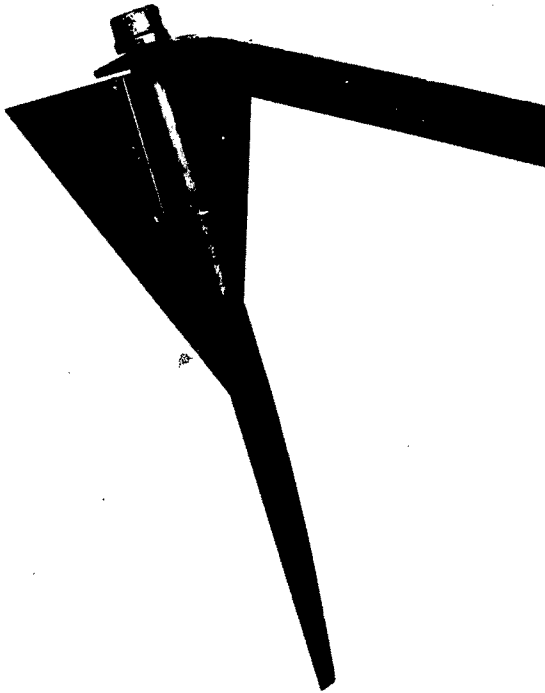


Fig. 1.

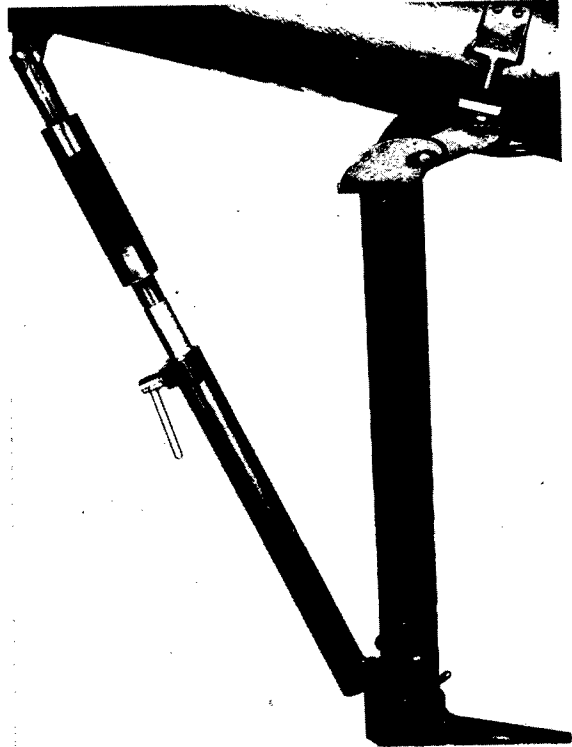


Fig. 2.

Fig. 1. Spade such as may be attached to each leg of projector to anchor it securely to the ground.

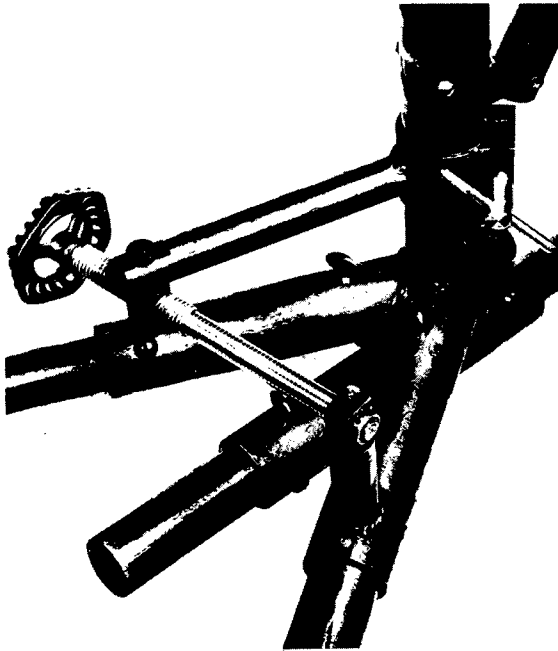


Fig. 2. Clamp and turnbuckle for coarse and fine elevation adjustment, projector No. 5.

Fig. 3. Clamp and handwheel for coarse and fine adjustment of azimuth, projector No. 5.

Fig. 3.

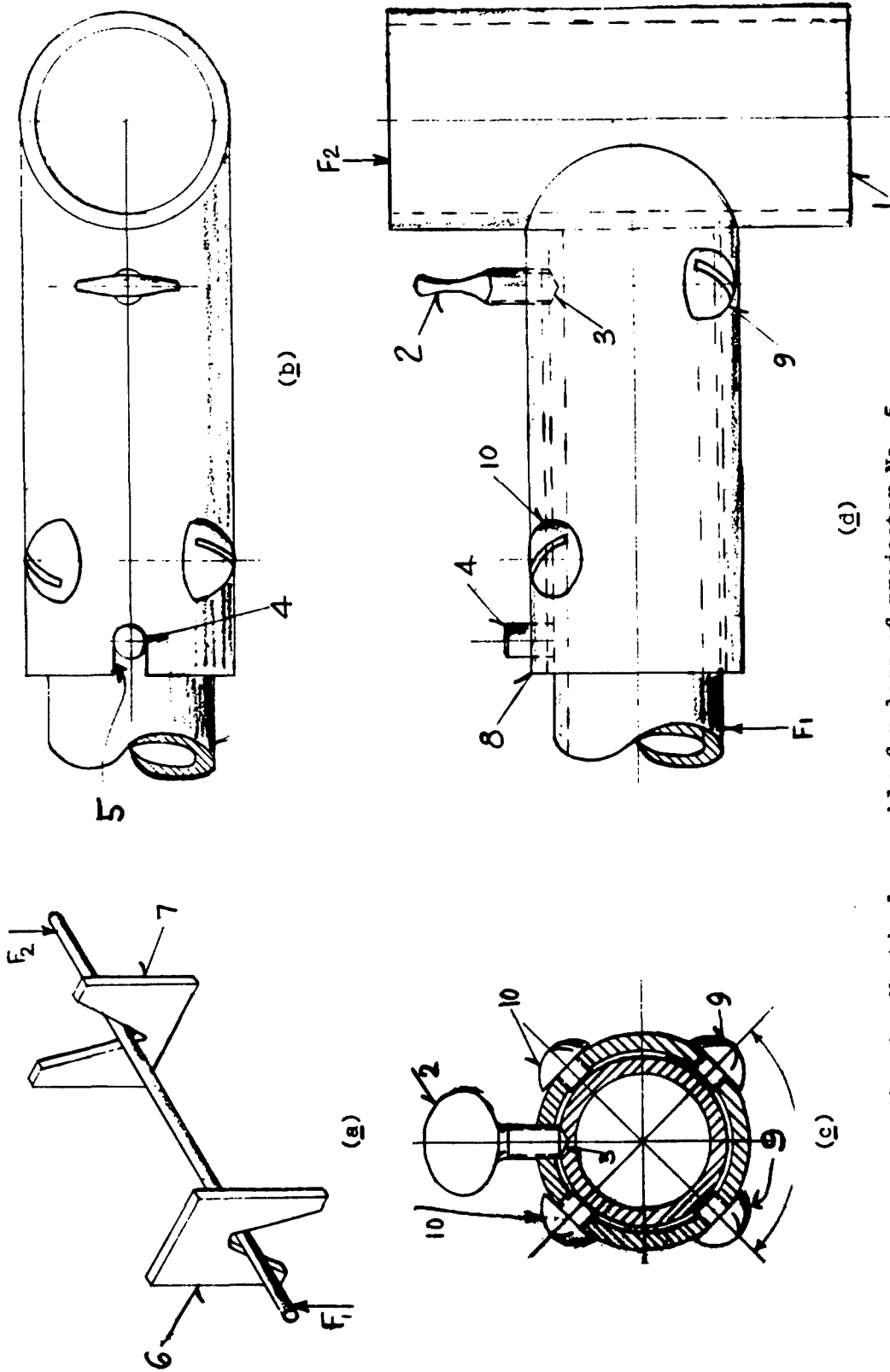
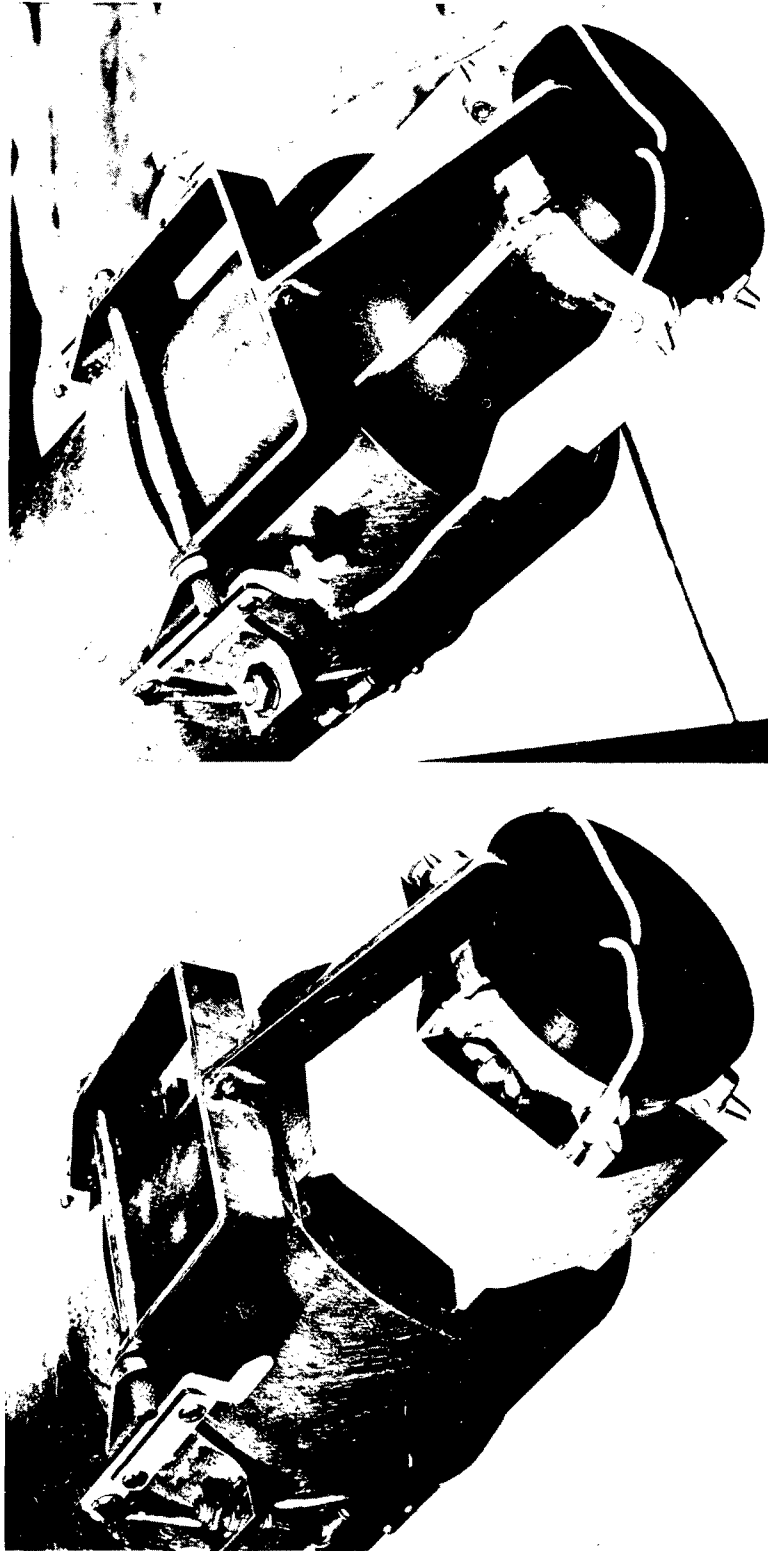


Fig. 4. Vertical assembly for legs of projector No. 5.



(b)

(a)

Fig. 5. Breech mechanism. (a) Tape holds fins and wires for easy entrance into projector without injury to fins. (b) Tape torn off and wire clips connected to terminal plugs that provide firing potential.



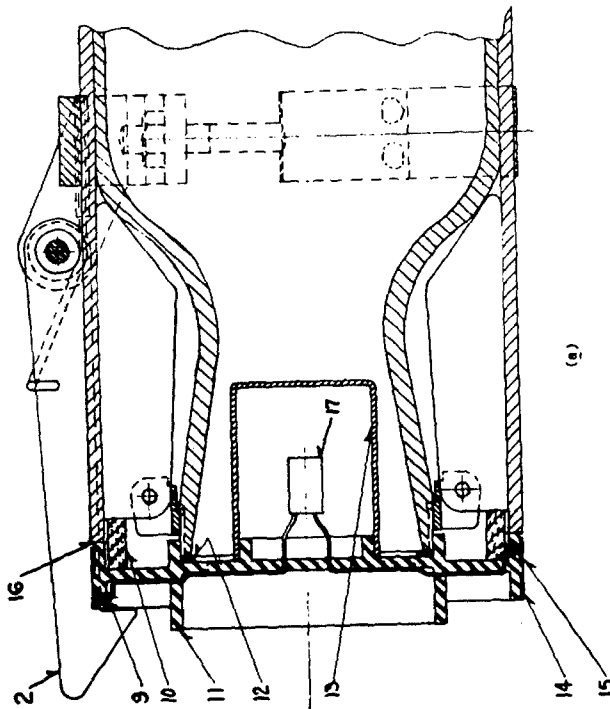
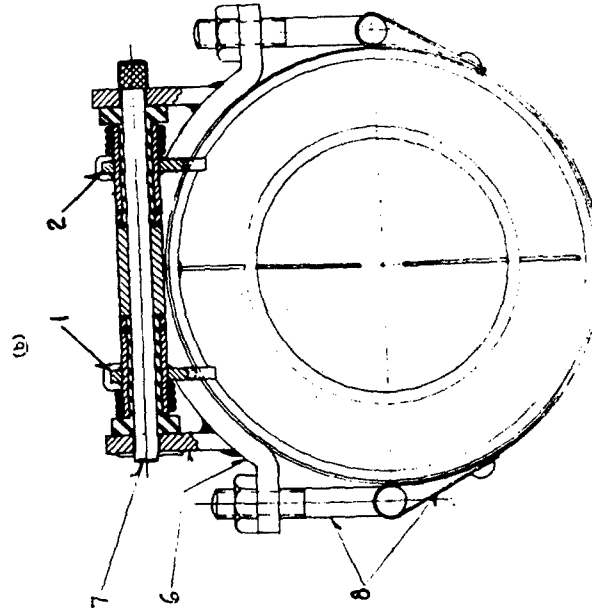
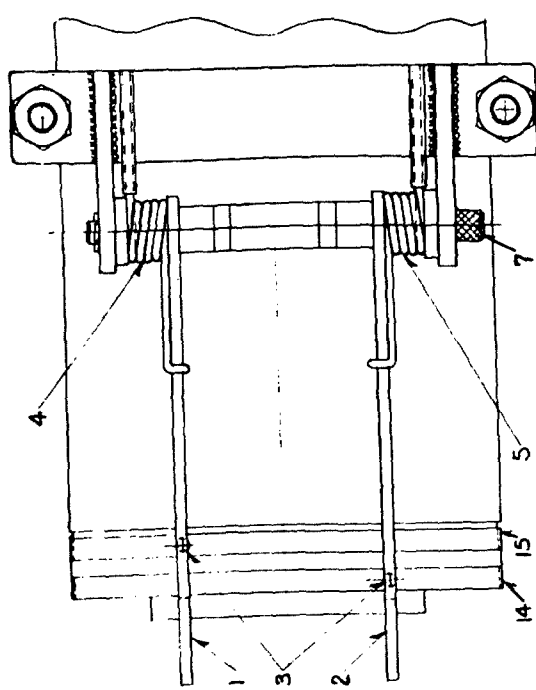
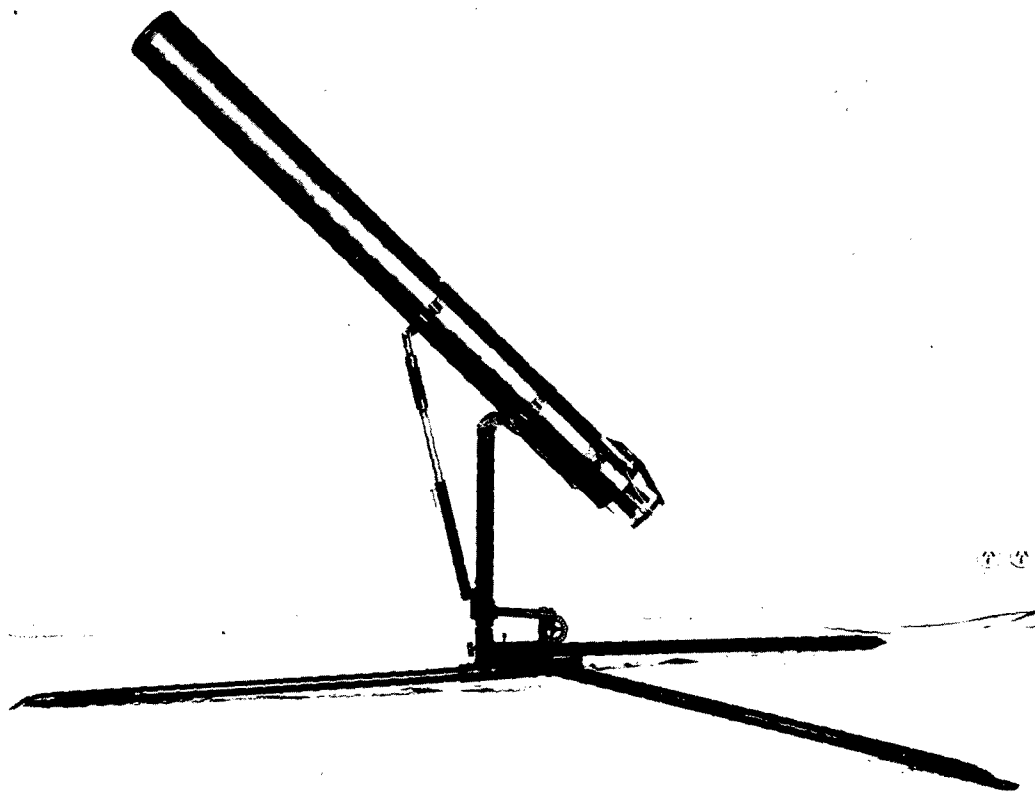
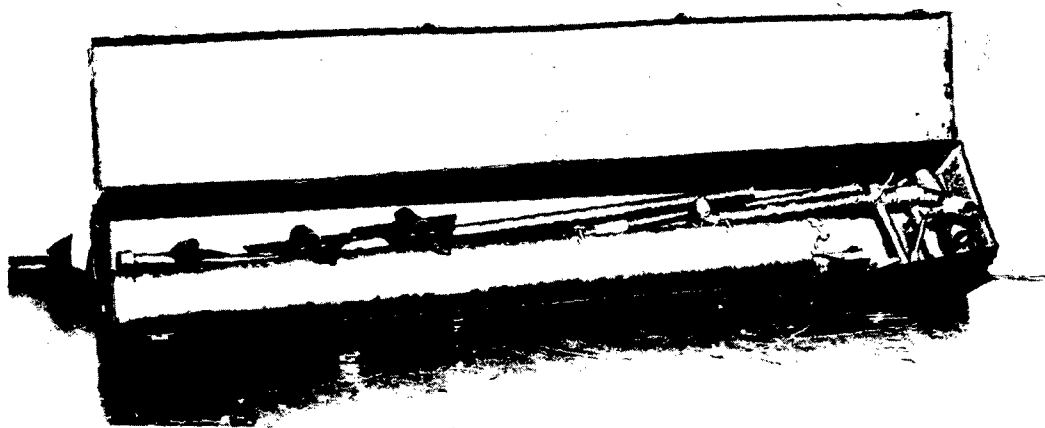


Fig. 6. Six-purpose breech plug. The plug seals the opening of the venturi with a gasket 12, presses fin against the body of the projectile with cardboard annulus 10, provides a stop in the forward direction by butting against the projector 16, provides a stop in the backward direction by engaging in a notch of the hook 2, provides two slip rings 14 and 15, and provides a mounting for the squib cap 13.



(a)



(b)

Fig. 7. (a) Projector No. 5 assembled with rocket in place and (b) projector in a carrying case measuring 9 in.  $\times$  10 in.  $\times$  6 ft. The total weight of projector and case is 80 lb.

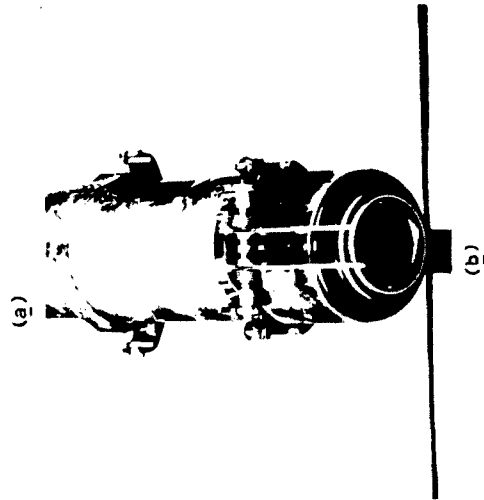
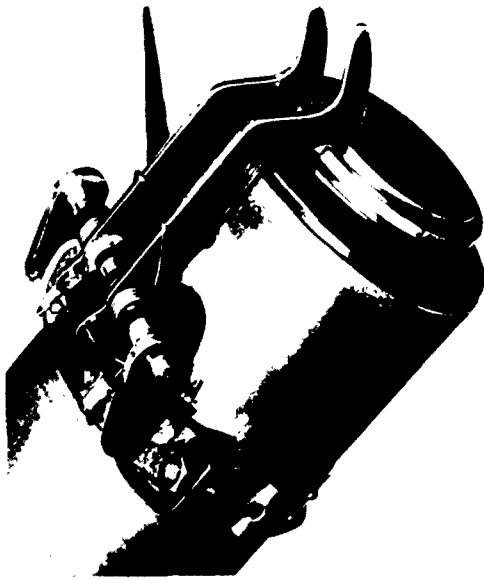


Fig. 9. Automatic contacting device on projector 5A. (a) Side view of breech showing hooks in contact with slip rings. (b) Rear view of breech.

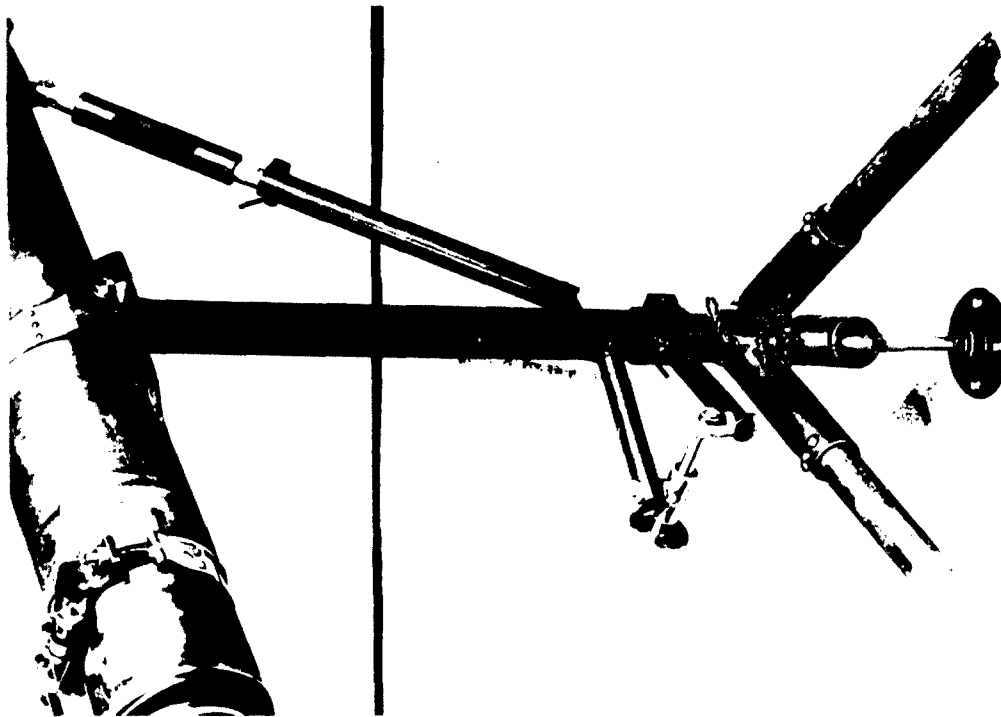
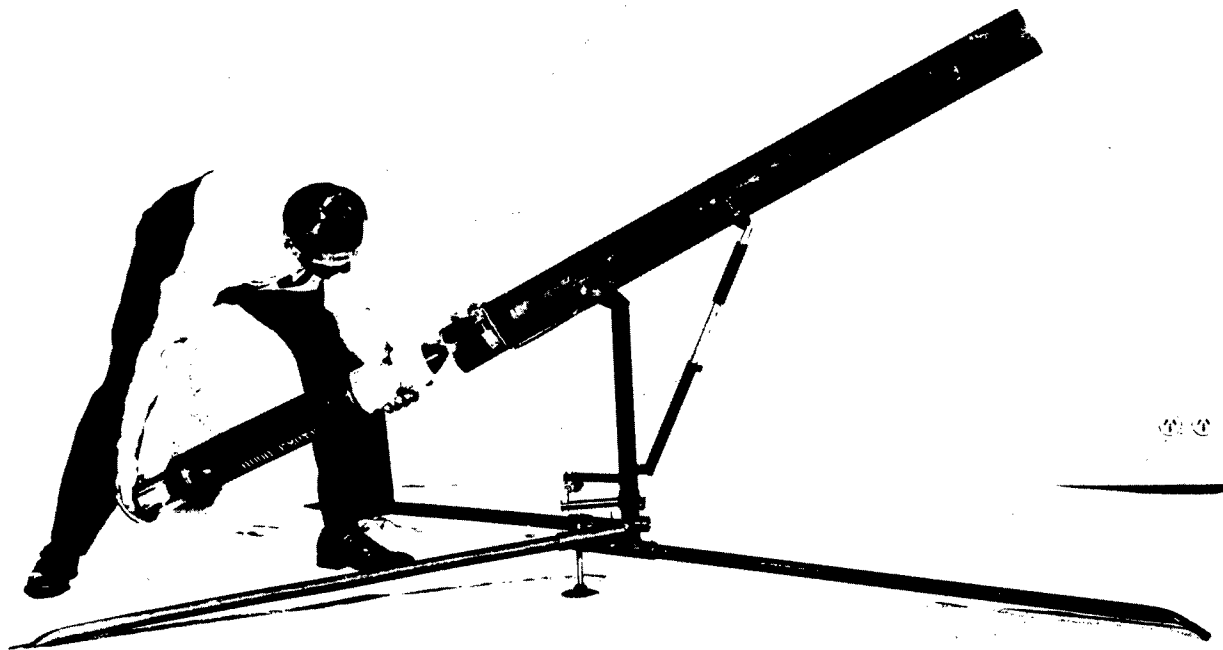
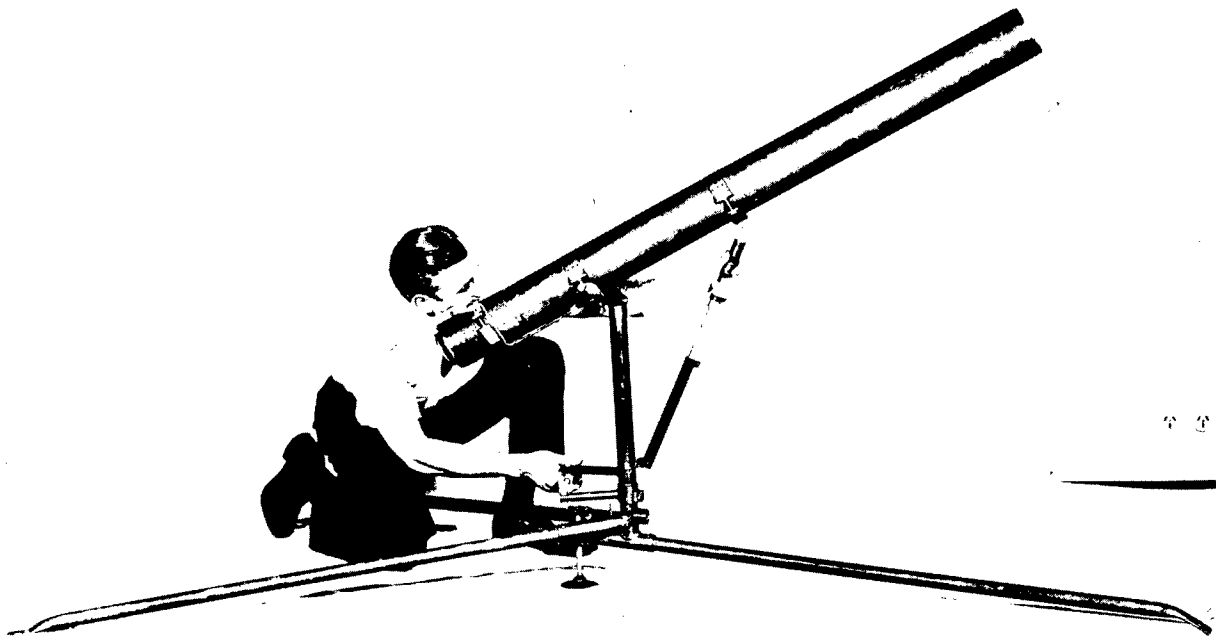


Fig. 8. Projector 5A, showing center support and projecting sleeves that protect screw threads for azimuth and elevation adjustment.

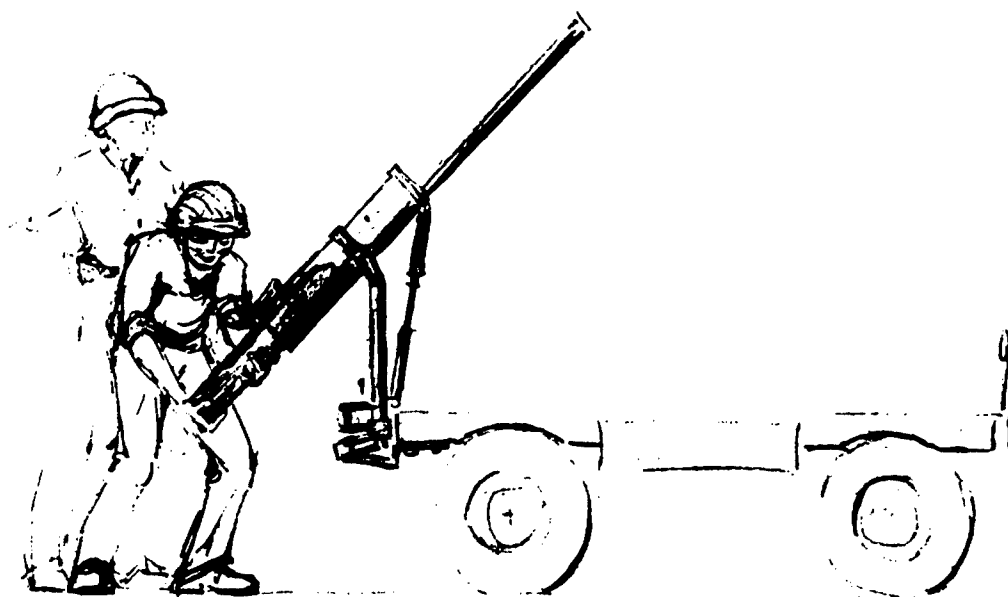


(a)



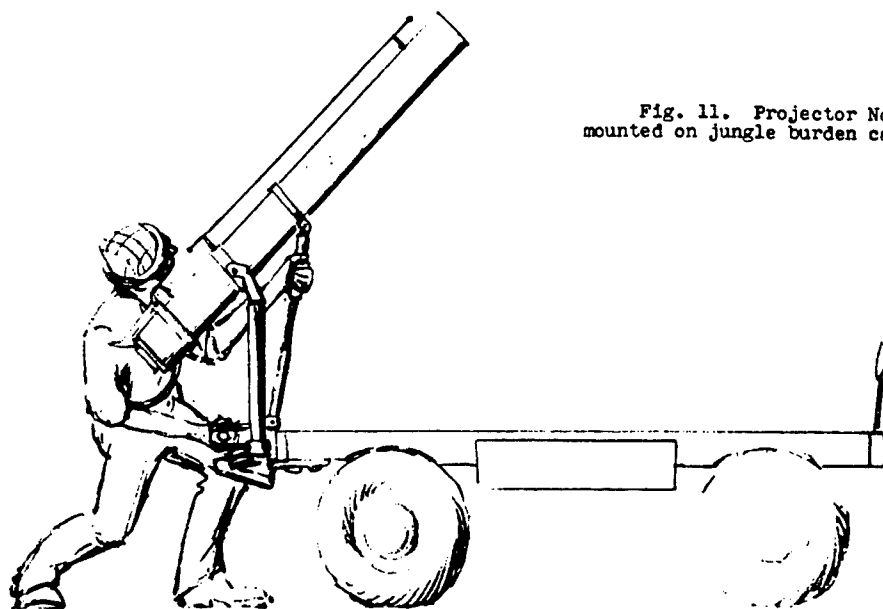
(b)

Fig. 10. (a) Loading projector No. 5A and (b) making fine adjustment of azimuth and elevation.



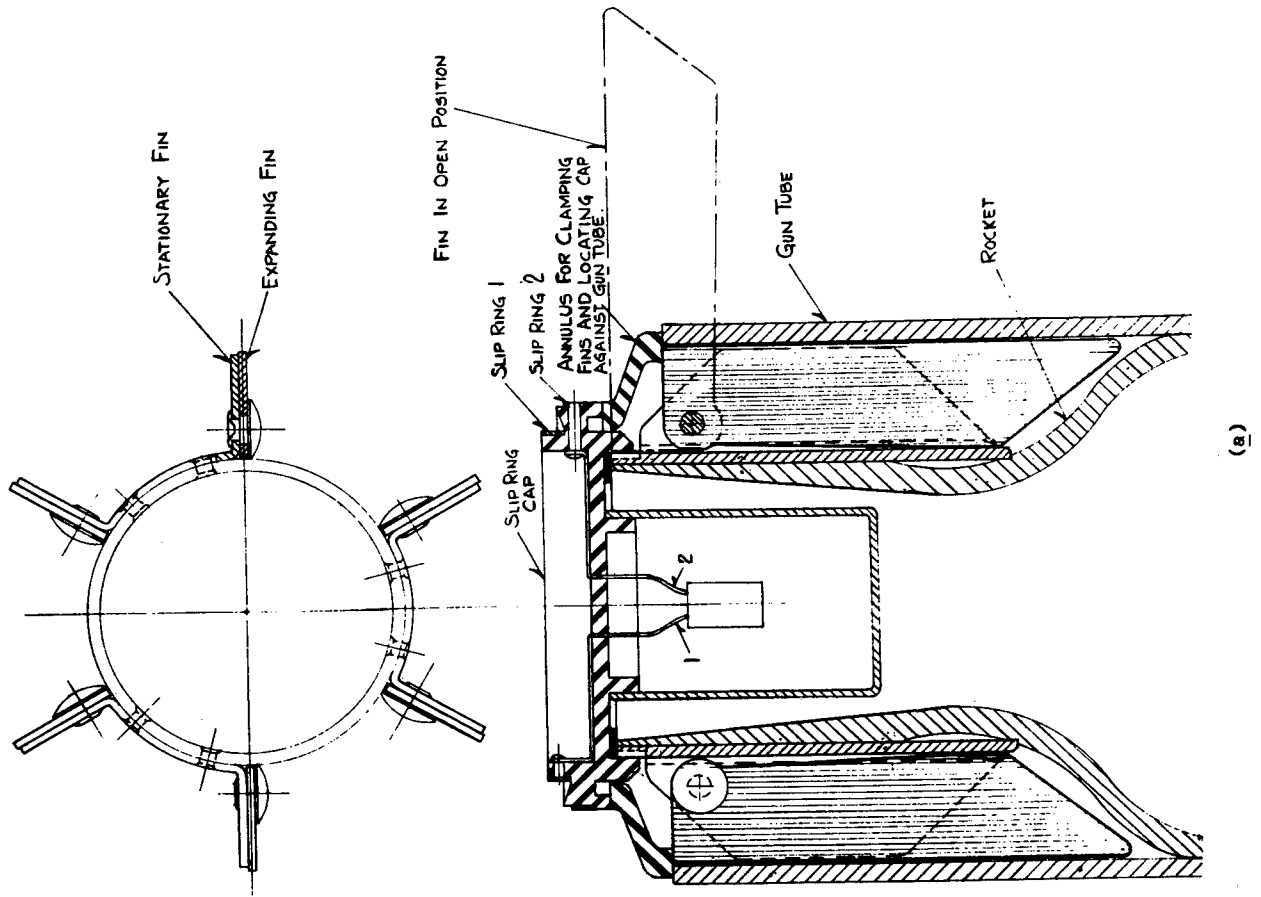
(a)

Fig. 11. Projector No. 5A  
mounted on jungle burden carrier.



(b)

Fig. 12. (a) Drawing of contact cap and fin assembly, (b) rocket in place in projector showing contact cap and fin assembly.



(b)

(a)

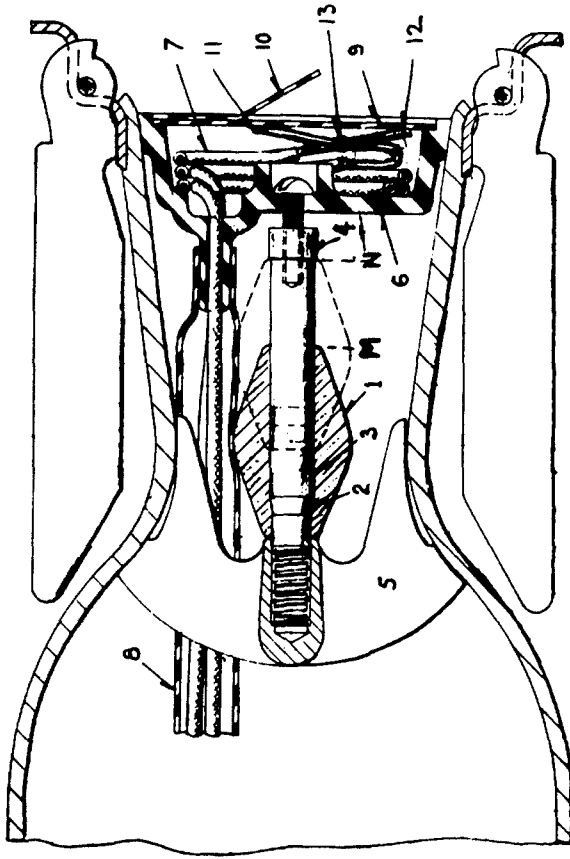
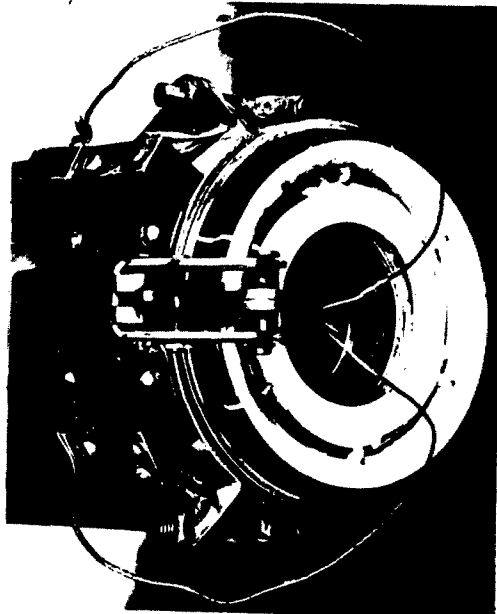


Fig. 14. Detail of contact cap and fin assembly for rocket to be fired in projector No. 6.

Fig. 13 (left). Two views of the breech of projector No. 6 showing appearance of projectile breech when inserted in projector and the method of connecting ignition wire of the projectile to the projector.



(a)



(b)

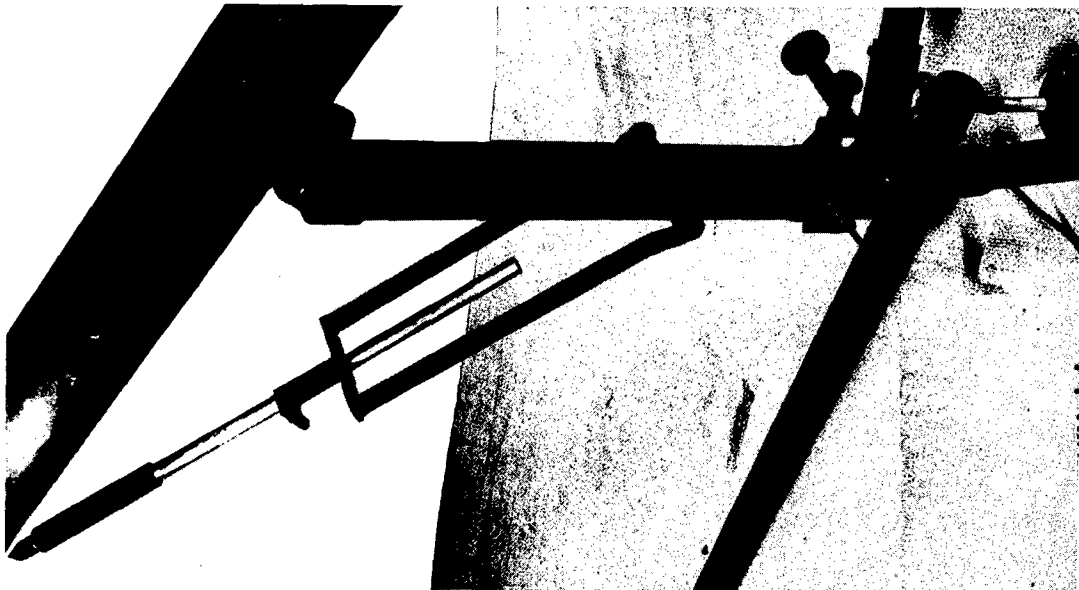


Fig. 16. Projector No. 6 set up for firing. Inset: card-board container for use of paratroops.

Fig. 15 (left). View of azimuth and elevation adjustments of projector No. 6. Also note the larger vertical column.



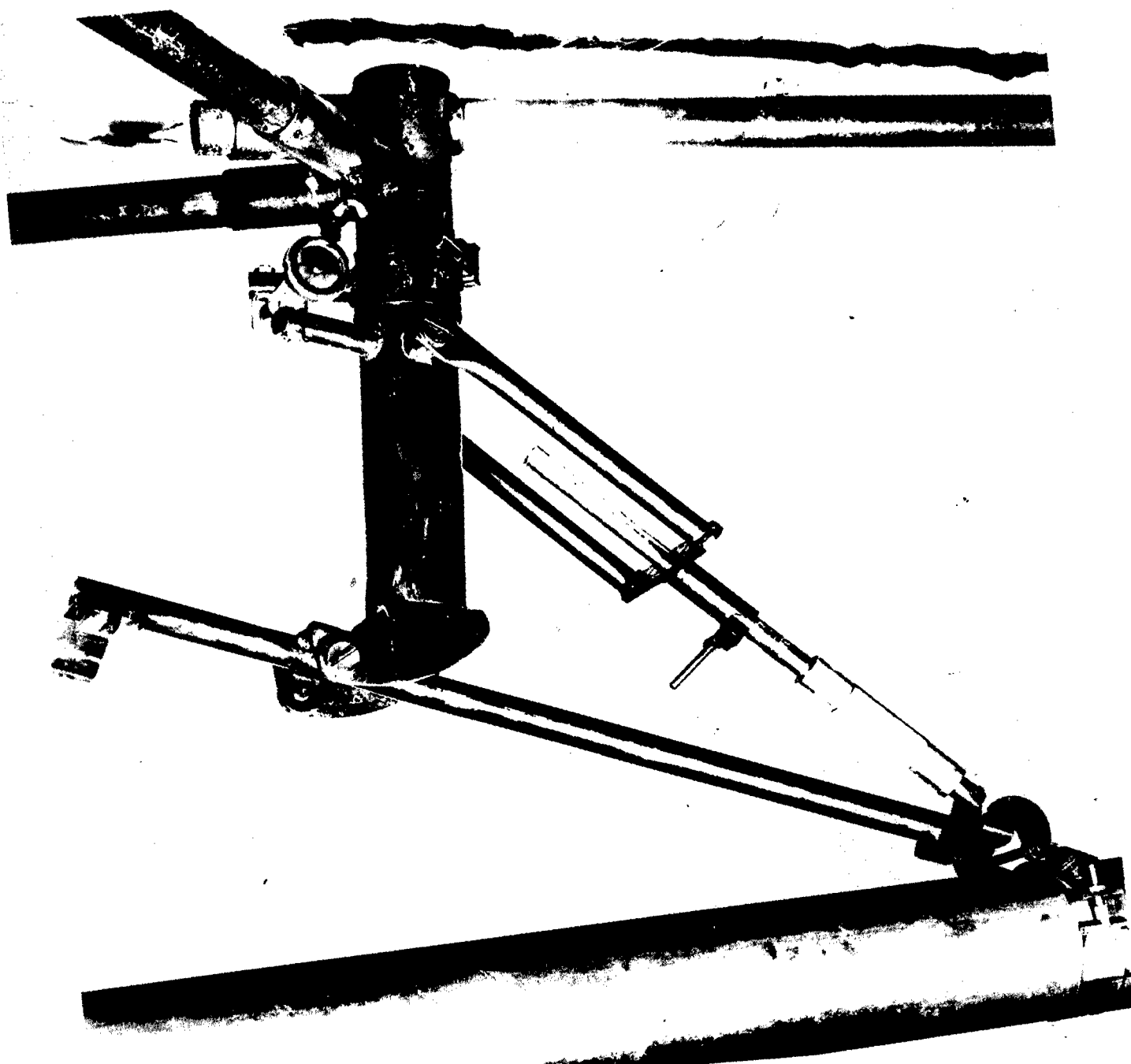
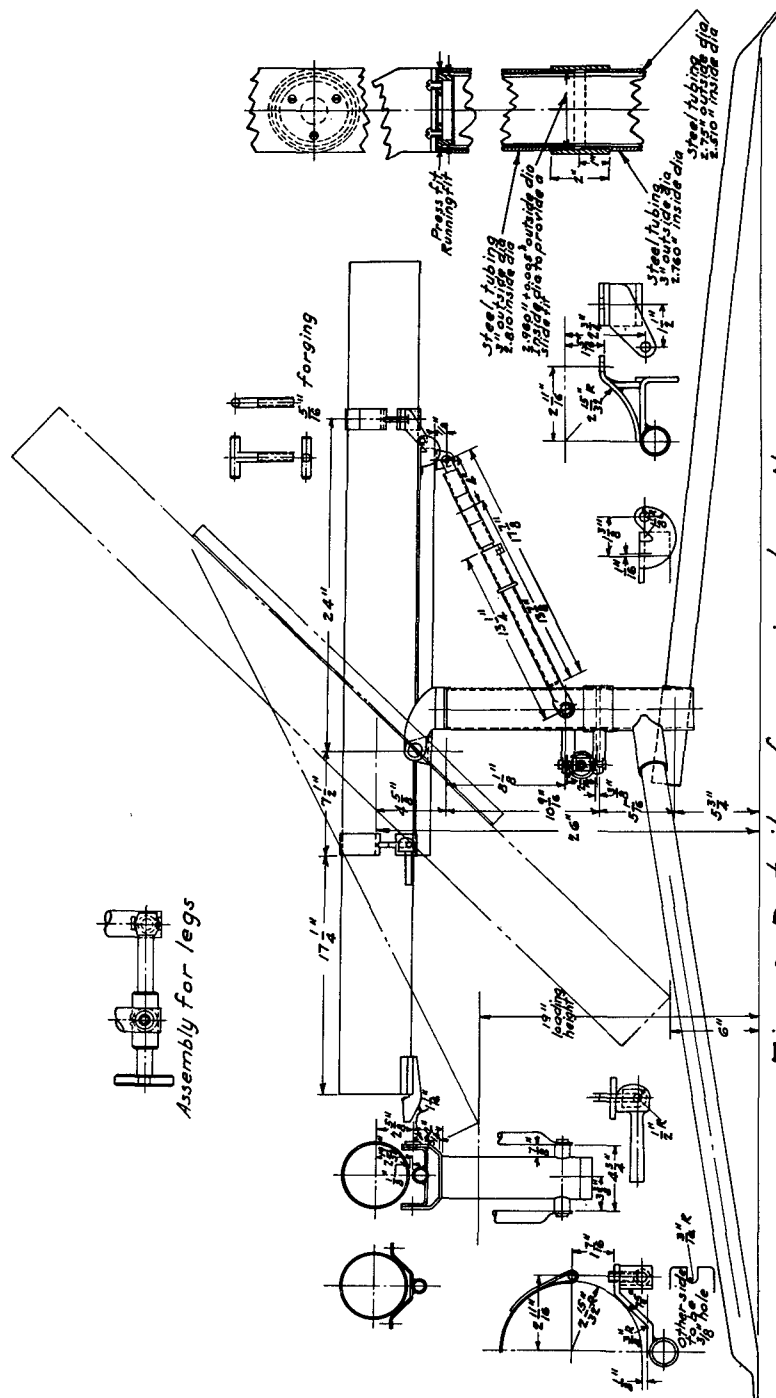
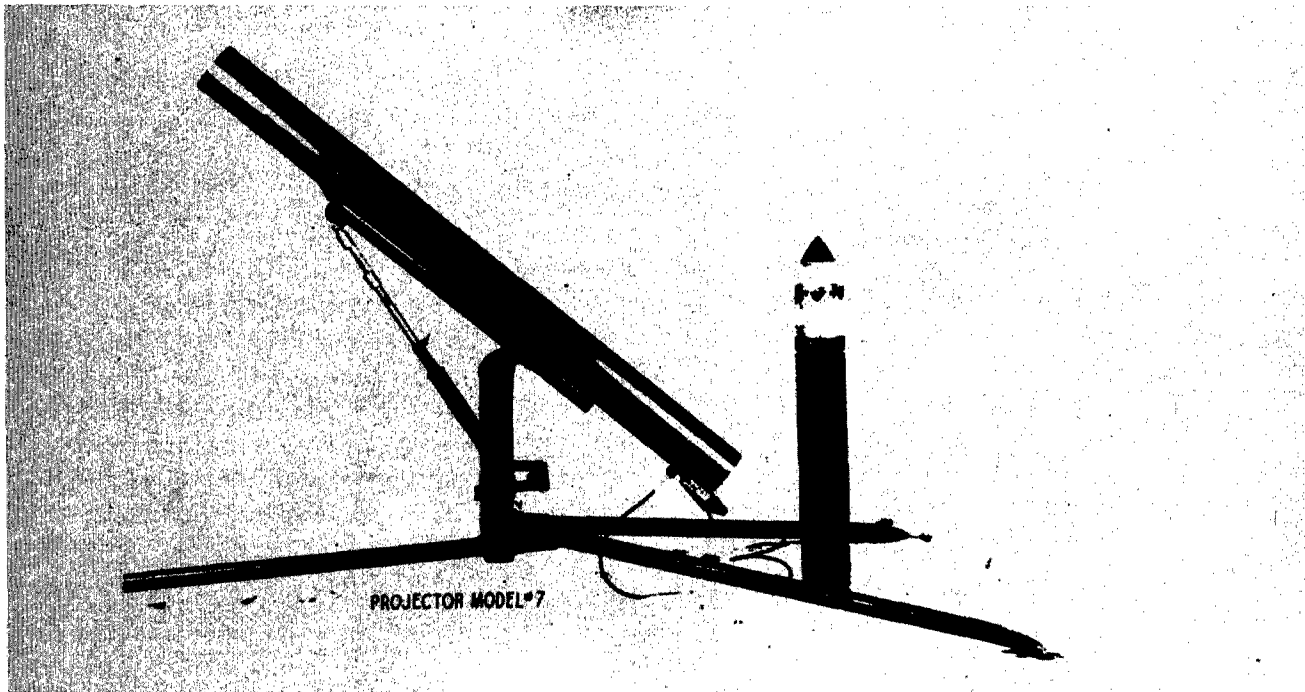


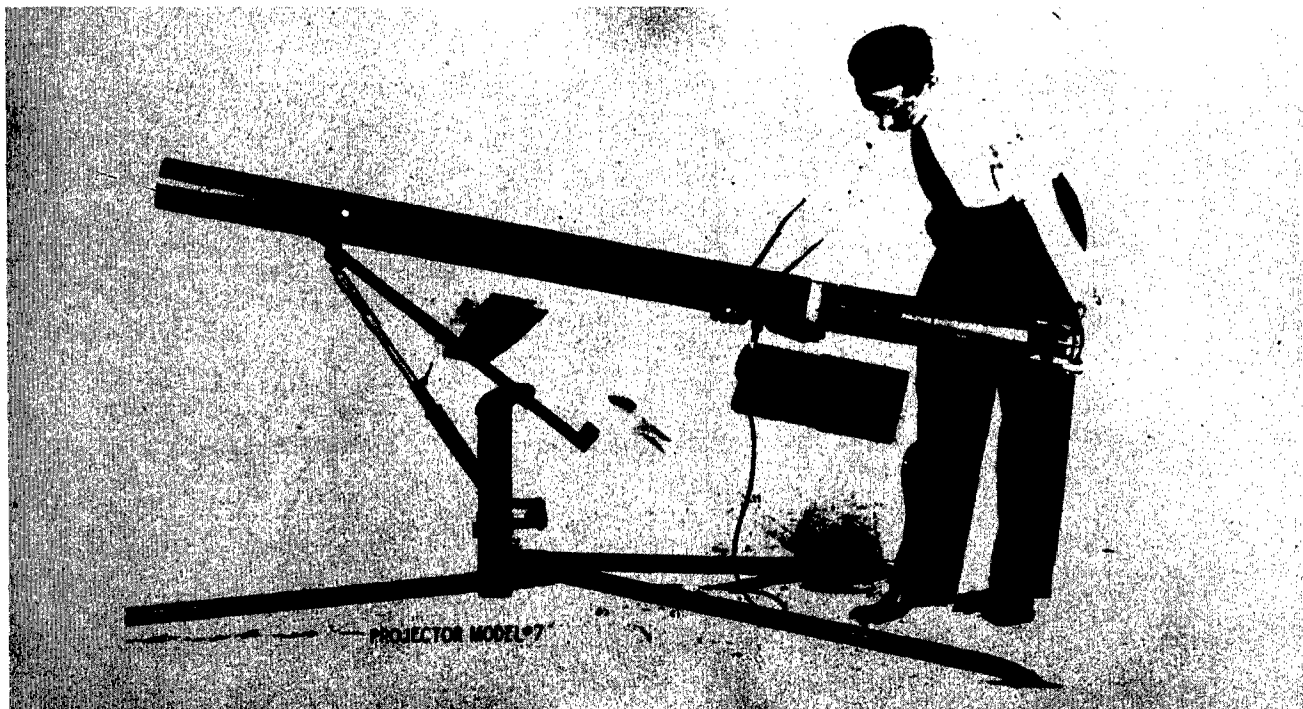
Fig. 17. The auxiliary frame that facilitates loading in projector No.7

ERRATUM  
Illustration on this page should be  
inverted for use.





(a)



(b)

Fig. 19. Loading of projector No. 7 when set for high elevation.

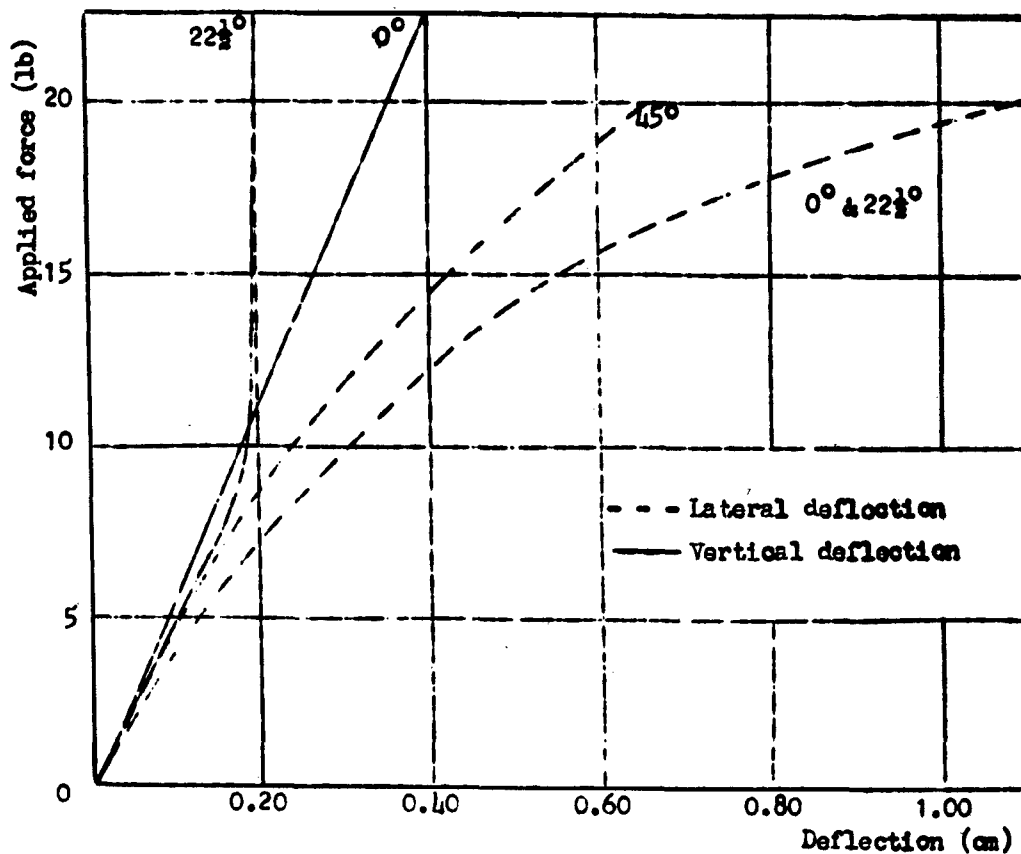
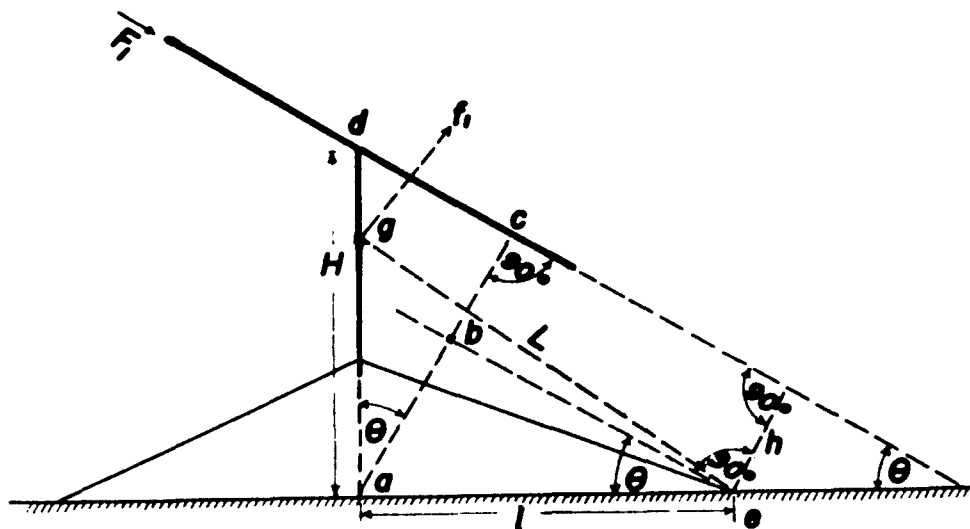


Fig. 20. Lateral and vertical deflection of front end of firing tube, projector No. 7, as functions of applied force and elevation. For 45° elevation, the vertical deflection did not exceed 1 mm up to a force of 20 lb. The angle of elevation is shown on each curve.



$$f_i L = F_i h$$

$$f_i = \frac{F_i h}{L}$$

$$\overline{dc} = H \cos \theta$$

$$\overline{ab} = l \sin \theta$$

$$\overline{dc} - \overline{ab} = h = H \cos \theta - l \sin \theta$$

$$\therefore f_i = \frac{F_i (H \cos \theta - l \sin \theta)}{L}$$

FOR  $\theta = 0^\circ$

$$f_i = \frac{F_i H}{L}$$

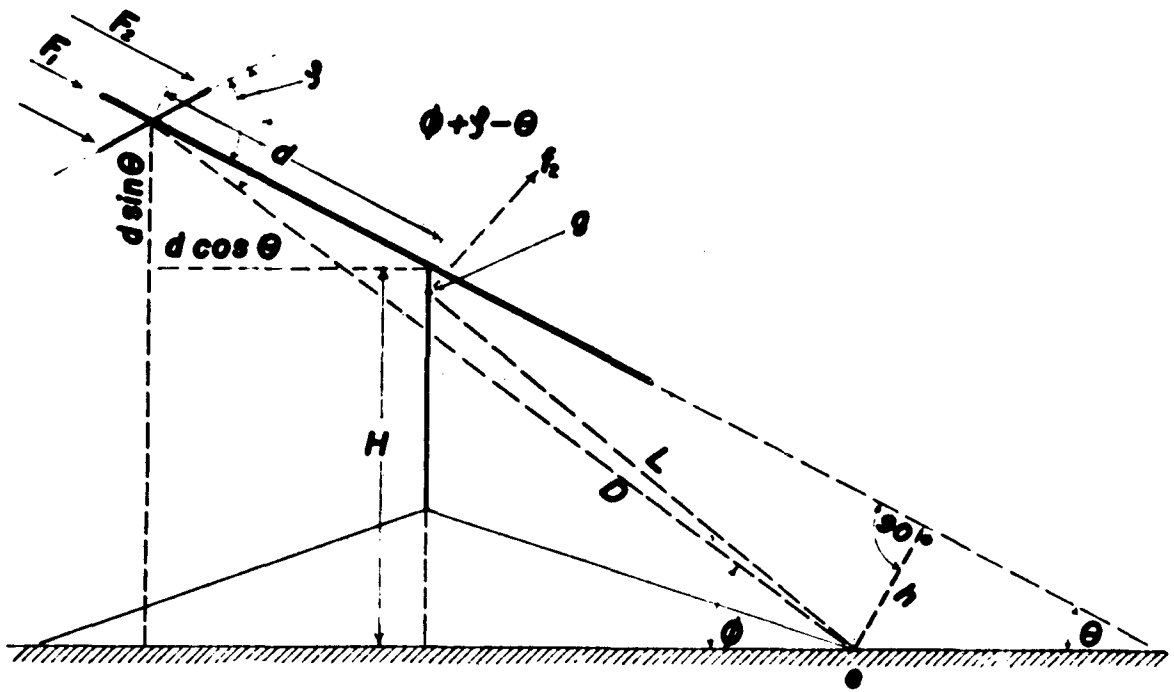
FOR  $\theta = 30^\circ$

$$f_i = \frac{F_i (.866H - .5l)}{L}$$

FOR  $\theta = 45^\circ$

$$f_i = \frac{.70 F_i (H - l)}{L}$$

FIG. 21



$$f_2 = \frac{(F_1 + F_2 \sin \psi) h}{L} - \frac{F_2 D \cos(\phi + \psi - \theta)}{L}$$

FOR  $f_2 = 0$

$$(F_1 + F_2 \sin \psi) h = F_2 D \cos(\phi + \psi - \theta)$$

$$h = H \cos \theta - l \sin \theta$$

$$D = \sqrt{(d \cos \theta + l)^2 + (H + d \sin \theta)^2}$$

$$\phi = \sin^{-1} \frac{H + d \sin \theta}{D}$$

FIG. 22



PART II  
JUNGLE LAUNCHER

INTRODUCTION

A ground launcher for the 4-1/2 in. rocket was designed which weighs approximately 20 lbs. It is provided with adjustment for mounting height, azimuth and range.

On November 17, 1943, Dr. R. E. Gibson and Major H. G. Jones discussed with the Bell Telephone Laboratories the development of a rocket launcher for jungle warfare. The General Electric Company had designed such a launcher and had manufactured 1200 sets. Shortly before these launchers were ready for shipment, reports came from the South Pacific theater of war indicating that this launcher was inadequate because it was too low and had no adjustment for height, elevation and azimuth.

PROBLEM CONSIDERATIONS

The requirements of a new design as set forth by Major Jones were as follows. The launcher should be adjustable in height from 10 in. minimum to 48 in. maximum. It should have adjustment for azimuth and adjustment of plus or minus 10° in elevation. The weight including rocket, spacers and wire spools should not exceed 60 lbs. This meant that the launcher proper should weight not more than 20 lbs. The launcher is to be expendable after a single shot. The



time necessary for unpacking and setting up should not exceed 2 min. The cost of such a launcher should be low.

#### DEVELOPMENT AND TESTS

The first model that was made by the laboratories Fig. 1, Page 51, was demonstrated and tested at Aberdeen Proving Ground on November 23, 1943. Two shots were fired. The launcher was blown back about 25 ft. and separated into three parts - the launcher tube, the vertical column and the base. The bracket holding the launcher tube to the vertical column was slightly bent and four rivets were torn off. There was no other damage, since this launcher was not intended to be used a second time any injury that did not interfere with the accuracy of the first shot was not important. Nevertheless it was decided to try a second shot from the launcher. After the bracket was straightened, the rivets were replaced by nails and a second shot was fired. This time the nails simply pulled out without bending the bracket.

Pictures of the first shot taken with a high-speed camera showed that the tube was slightly pushed back before the rocket left the muzzle. However, inasmuch as the mass of the launching tube is only 10 lbs. as compared to the 40-lb. mass of the rocket, it was thought that any motion of the launching tube could not appreciably deflect the course of the rocket.

After the demonstration it was decided to make another launcher that could be fired more than once. Adjustable legs

were provided so that the mount could be set up on slopes or uneven terrain.

Launcher No. 2 was finished on November 29, 1943 and tested at Aberdeen Proving Ground on November 30, 1943. Four shots were fired. In each case the launcher tube detached itself from the vertical column without doing any damage to the tube or azimuth and elevation adjustment bracket. The launching tube and mount were thrown back about 30 ft. After the second shot one leg was broken and the U-bolts holding the vertical column to the base were bent. The first two shots were fired with the tube at a height of 4 ft., the other two with the tube at a height of 1 ft.

Figure 2, Page 51, shows several frames taken with a high-speed camera of one round fired on November 30, 1943. The launching tube L was mounted on the support S. A reference stake R was placed in line with the muzzle. In frame 1 the jet J is beginning. In frame 12 (the last frame before emergence) it may be noted that the launching tube has moved back about 2 in. This motion is no doubt due to the scrubbing action of the gases. There seems to be no change in the elevation. In frame 13 the rocket has emerged and the jet is impinging on the muzzle. It is this action that causes the launching tube to be hurled back.

Launcher No. 2 is shown in Figs. 3 to 6, Pages 52 and 53. The legs are made of wood, the vertical column of

plywood or plastic and the launching tube of plastic. The firing mechanism consists of two spools of wire that are soldered to the rocket and unwound after the launcher is set up. The weight of the complete outfit that the soldier must carry on his back is 62 lbs. This includes the rocket, 38 lb; launching tube, 10-1/2 lb; spacers and wire spools, 2 lb; vertical column, 1-1/2 lb; vertical column bracket, 1 lb; launching tube bracket, 2 lb; and base, 7 lb.

On direction from the Army and NDRC, drawings and models of both Jungle Launchers were turned over to the General Electric Company.

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Fig. 6 Launcher No. 2, Launching Tube Adjusted to a Height of One (1) Foot	53

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December 1, 1943, Memo for File by R. F. Mallina on the Jungle Launcher.

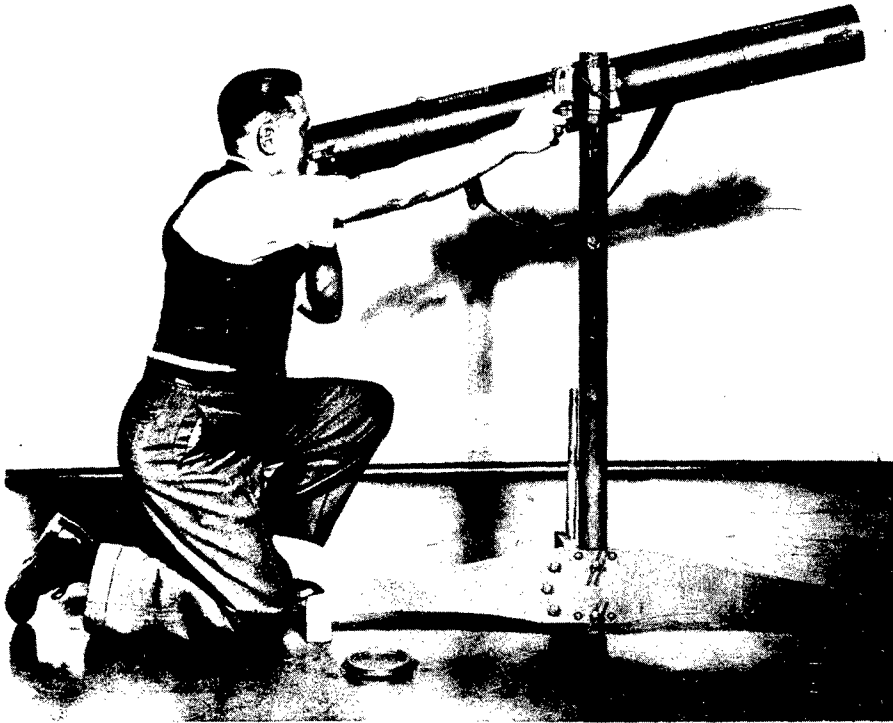
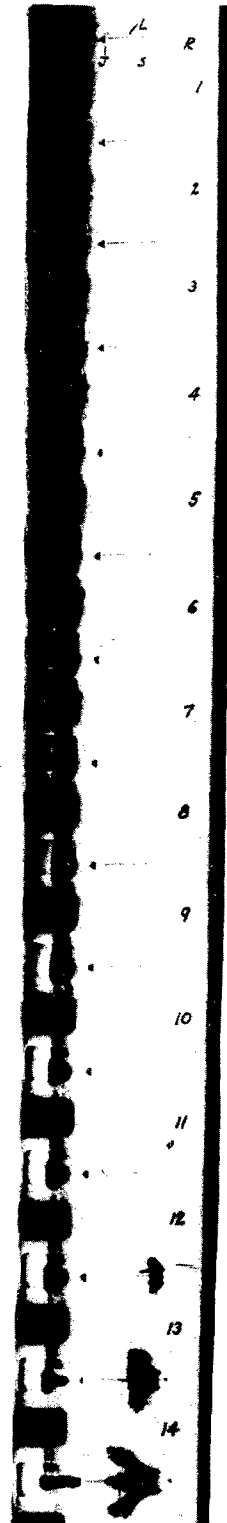


Fig. 1. Launcher No. 1 adjusted to 4 ft.

Fig. 2 (right). High-speed pictures of shot fired with launcher No. 2.



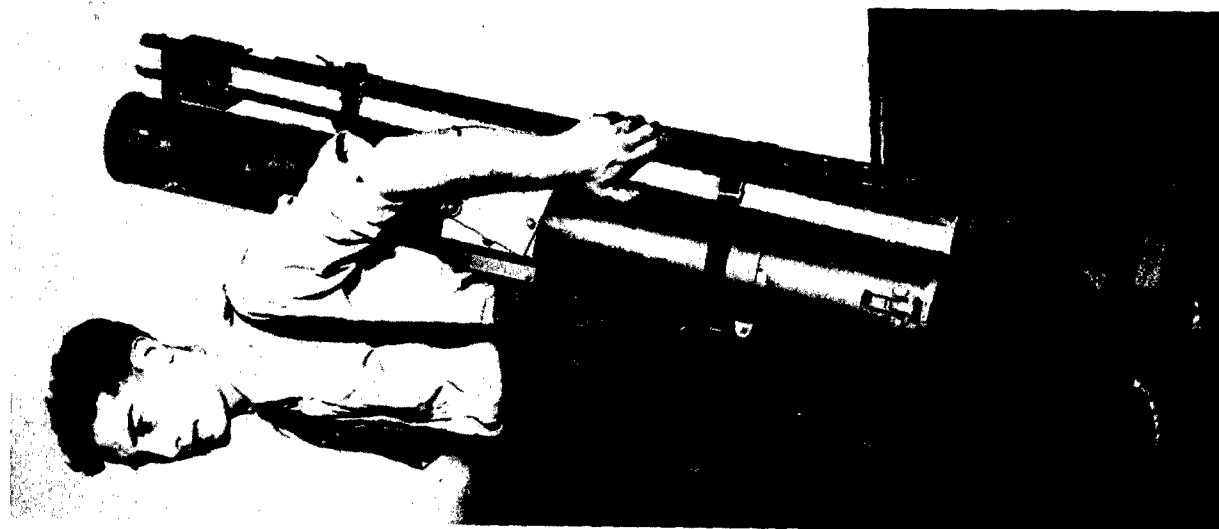


Fig. 3 (left). Launcher No. 2 carried like a rifle.



Fig. 4. Launcher No. 2, launching tube adjusted to a height of 4 ft.



Fig. 6. Launcher No. 2, launching tube adjusted to a height of 1 ft.

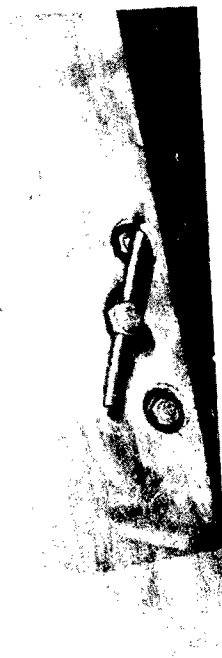
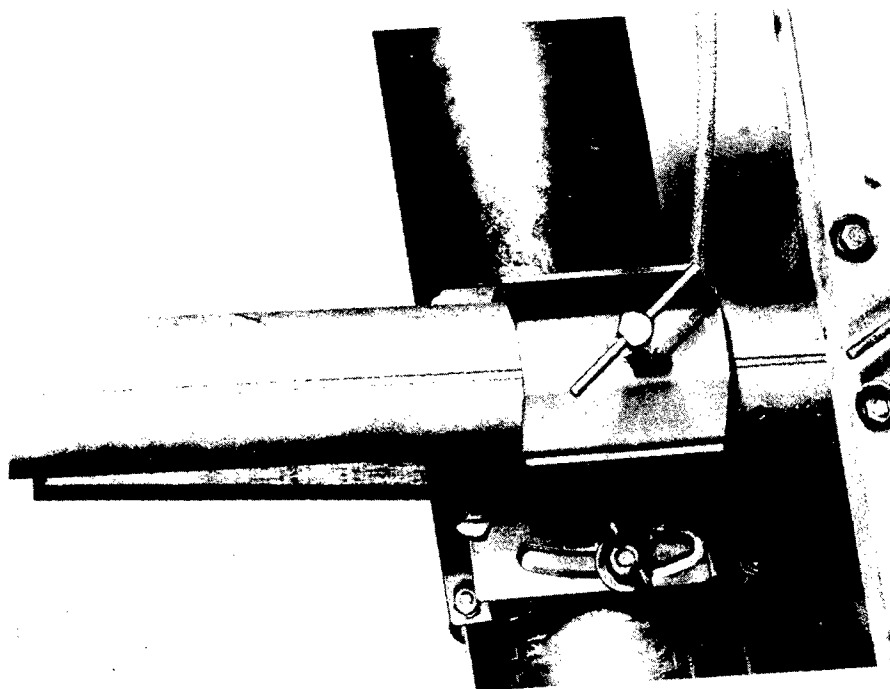


Fig. 5 (left). Launcher No. 2, close-up of adjustment bracket.



PART III  
REVOLVING PROJECTOR

INTRODUCTION

In discussions held between engineers of the Bell Telephone Laboratories and the Jet Propulsion Research Laboratories, Indian Head, Maryland, the latter expressed belief that valuable information could be obtained from the effect of the rotation of a rocket on its dispersion, by constructing a short projector which could be revolved at various speeds and the rockets fired while being thus rotated. It was the policy of the Bell Telephone Laboratories to confine their contributions to electrical problems, however when it was pointed out that the Jet Propulsion Research Laboratory was having difficulty in finding anyone to design this projector and that Mr. R. F. Mallina was particularly well fitted to take on the assignment, the Laboratories consented to build the model.

DESCRIPTION OF PROJECTOR

The projector, photograph 116563, page 59 , consists of a four foot length steel tube mounted within a larger steel tube and rotating on ball bearings. The larger tube is mounted by means of 2 pivot bolts to a tripod base. The legs of this base are removable to facilitate transportation. A slide mechanism (shown better in photograph 116566, page 63 ) between the base and the large tube is used to permit both coarse

and fine elevation adjustments. The course elevation adjustment is made and held by means of a clamp. A turnbuckle immediately above the clamp is provided for fine adjustment. The screw threads of this adjustment are covered by a protecting sleeve.

A 1-1/2 hp 10 volt capacity induction motor with a power belt drive is used to rotate the launching tube as shown on photograph 116568, page . The two slip rings and associated brushes are provided to transmit ignition current to the projectile (see photographs 116564, Page , and 116565, Page ). Two clips are provided for attaching squib wires to the slip rings. Three pulleys are supplied which may be interchanged on the motor shaft to provide three speeds, 800, 1440, and 2400 rpm.

During the five days of testing, January 21, 24, 25, 26, and 27, 1944, at the Jet Propulsion Research Laboratory, Indian Head, Maryland, rockets were fired from this projector without rotation and at speeds of 800, 1440, and 2400 rpm. The results of these tests indicated that even a moderate rate speed of 800 rpm materially reduced the dispersion of the 4-1/2 inch rocket. The rockets fired from the projector were equipped with folding fins. When expelled from the projector the folding fins were quickly opened by the centrifugal force due to the rotation of the rocket. In view of the fact that the rocket was rotating at the time it was ejected from the projector, malalignment of the

jet and of the center of gravity of the rocket caused much less dispersion. During the course of the tests, rockets equipped with control valves in the nozzle were fired. Due to malalignment of the control valve the behavior of the jet was erratic and was equivalent to having a rocket with a poorly aligned nozzle. These rockets, when fired from the four foot projector without rotation, gave a probable error of dispersion as much as 70 mils. With rotation, the probable error of dispersion for the same type rocket was 13 mils. Another accurately manufactured group of rockets was fired. These rockets when fired from a 14 foot projector gave dispersions of about 17 mils. However, when fired from a 4 foot projector the dispersion was approximately 30 mils. When fired from the four foot rotating projector the dispersion was reduced to approximately 8 mils. As a result of these tests, it was evident that the effect of rotation was more pronounced for rockets which normally had large dispersion, even though the best rocket showed a notable improvement with moderate speed of rotation.

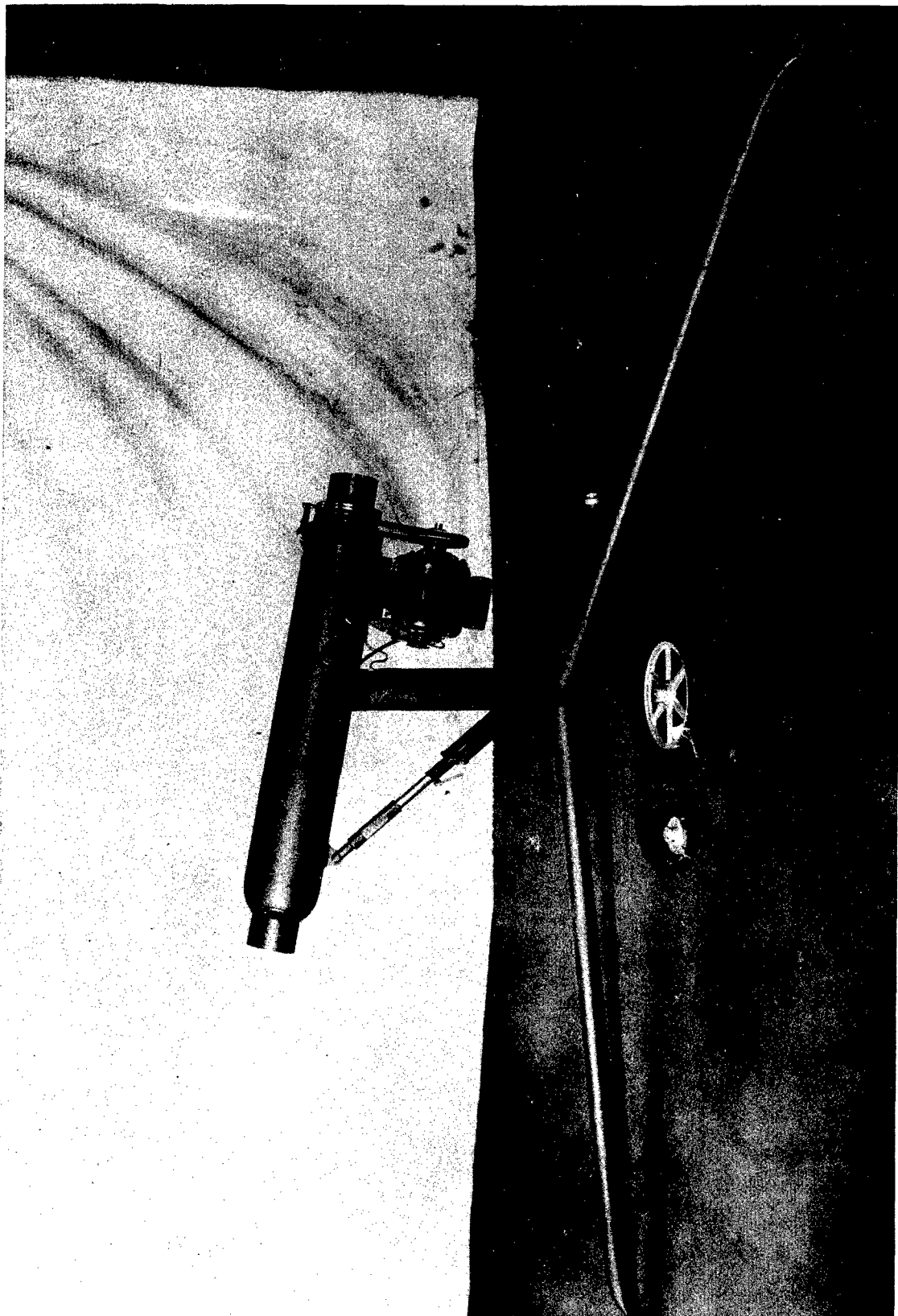
Tests had previously been made in which the rocket was caused to rotate by means of canted nozzles. The improvement in dispersion by the use of canted nozzles was not very marked. This is accounted for by the fact that the rocket does not get its maximum rotation until the burning is over. In the case of

the rotating projector the full speed of rotation is present at the time the rocket emerges from the projector so that all through the burning distance the rotation minimizes the ill effects of malalignment of the jet and of the center of gravity.

While it was not contemplated that rotating projectors would be used by the services the result of the tests indicated that it would be desirable to have the rocket rotating at a reasonable speed at the time it emerges from the projector. This resulted in the introduction of spiral projectors in which the rocket is caused to rotate by spiral grooves. The pitch of the spiral may be adjusted to give the desired speed of rotation. Projectors of this type are described in the Allegany Ballistics Laboratory report, Spiral Launchers, OSRD No. 5813. The tests made with the rotating Launcher are more thoroughly described in the Allegany Ballistic Laboratory report, Improvement of Components of 4.5 in Rocket M8 OSRD 5777.

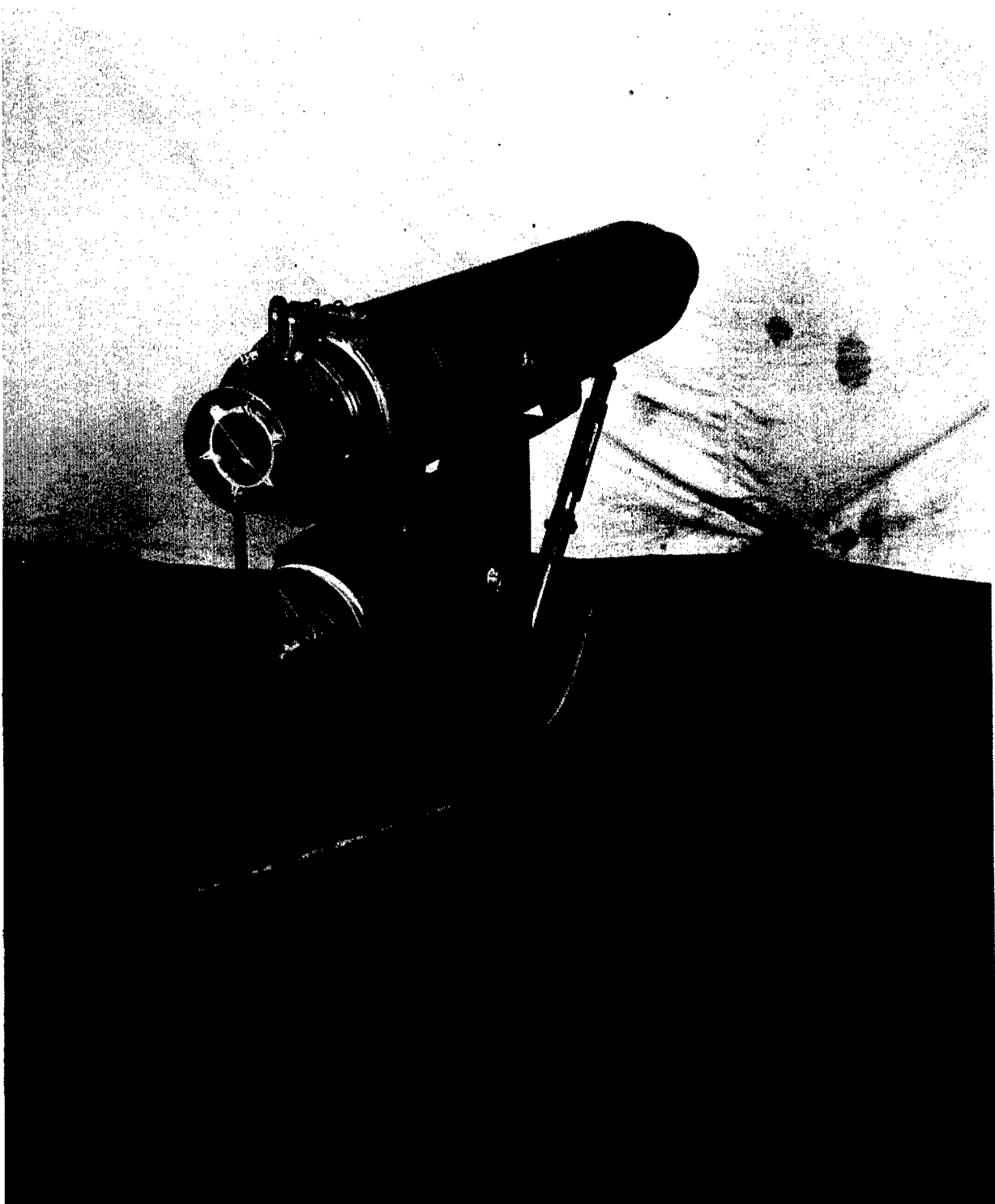
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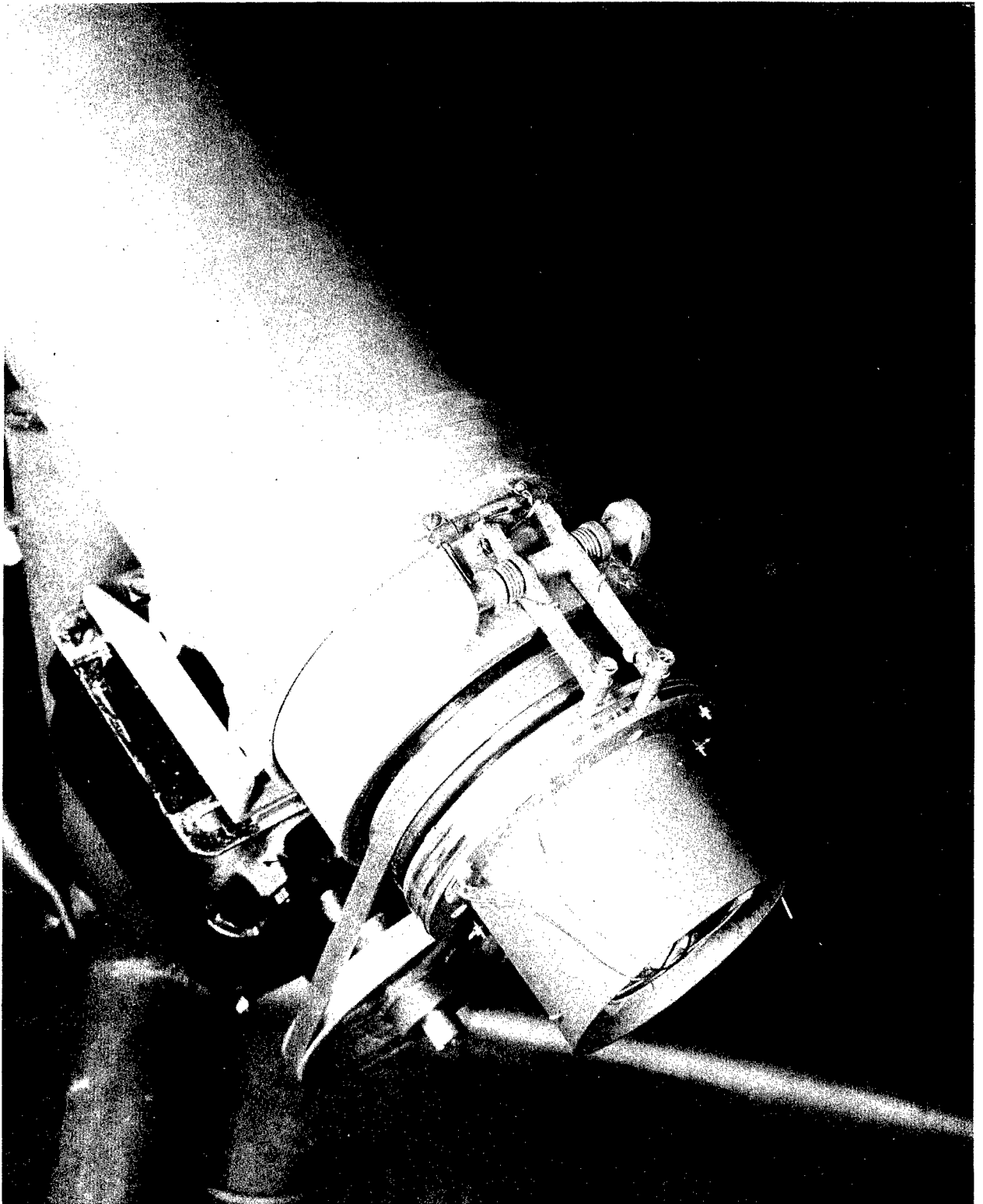
116 363

REVOLVING PROJECTOR FOR TESTING 4-1/2" ROCKETS



116568

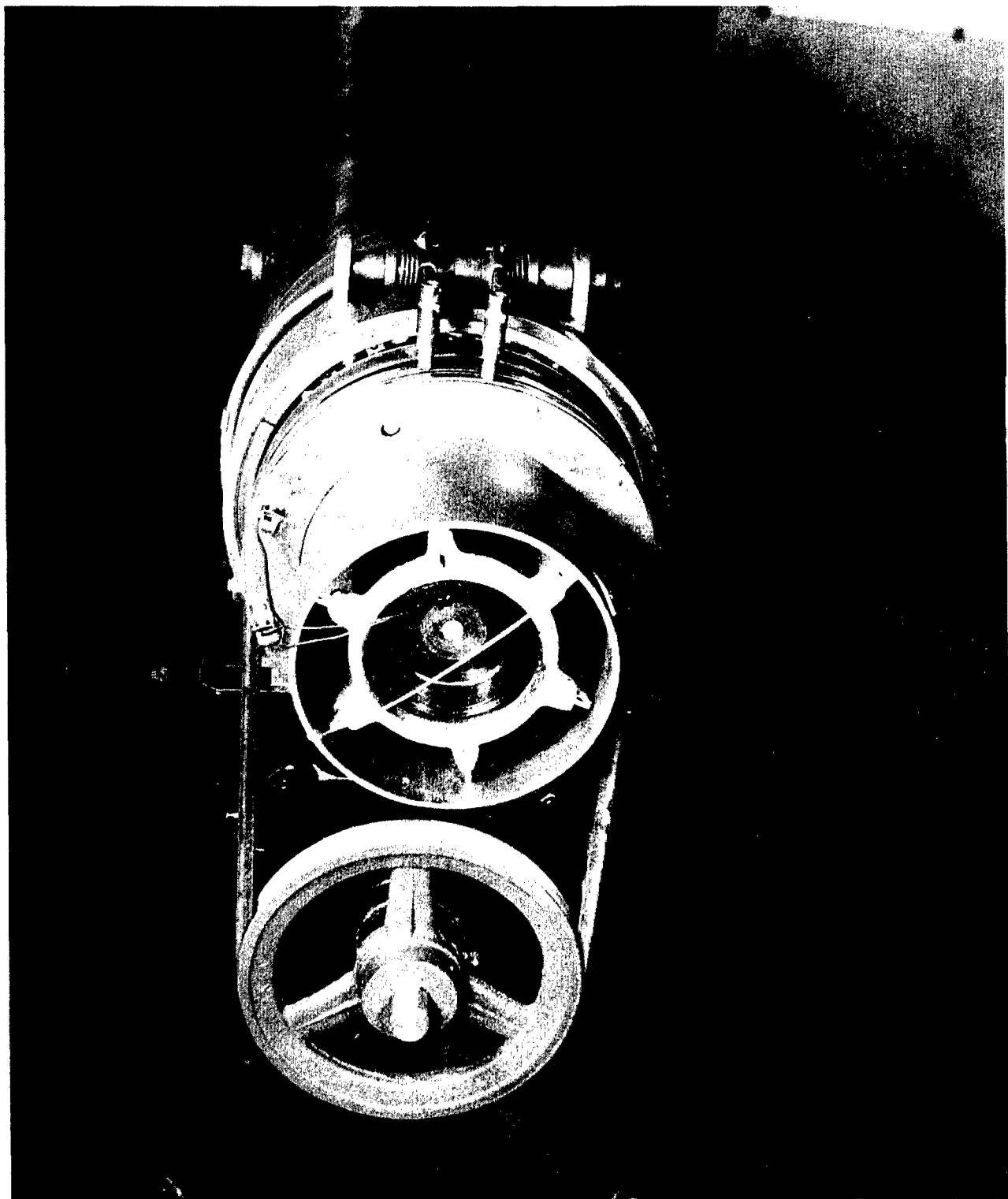
1-1/2" HP - 10 VOLT INDUCTION MOTOR AND POWER  
BELT DRIVE



111565

SLIP RINGS AND ASSOCIATED BRUSHES





116564

IGNITION CURRENT TRANSMITTED TO PROJECTILE  
FROM SLIP RING BRUSHES



116566

SLIDE MECHANISM FOR COARSE AND FINE  
ELEVATION ADJUSTMENTS



115577

FRONT VIEW OF REVOLVING PROJECTOR

## PART IV

DESIGN OF THE TAIL END OF THE4-1/2" ROCKETINTRODUCTION

The Bell Telephone Laboratories, Inc. was asked by the N.D.R.C. to redesign the tail end of the 4-1/2" Army rocket. The purpose of the redesign was to coordinate the parts which affected the ignition system. Inasmuch as the ignition system is intimately associated with other parts of the rocket and rocket launcher, the redesign could not be restricted to the ignition system alone, but had to be extended to the folding fin mechanism, the holding mechanism, the cowling, the fin retainer and fin protection.

DESCRIPTION

An arrangement which provides a stream-lined cowling which can be made by a deep drawing operation, is shown on Dwg. No. ESO-660556, Page 88. The holding groove is provided by a separate ring which could be made from brass tubing in a screw machine or by die casting. Each fin has a music wire spring which can fully open the fin. Drawing No. ESO-660832, Page 89, shows a similar assembly except for a simplified fin and nut which holds the assembly together. These two designs have the disadvantage of requiring an extra part for the latch groove. ESO-660824, Page 90, combined the groove in the cowling, but the friction which held the fin retainer to the cowling was difficult to control and the design was discarded.

In connection with the requirement to provide springs which would fully open the fins after rocket leaves launching tube, there was some concern about the fin rebound after it first strikes its back stop. To obtain some indication of this condition the fin action on a tail assembly with the music wire fin springs was observed by means of "shadow-graphs". The following conditions were observed.

1. Fin operated by its wire spring only.

The fin was observed to rebound once through an angle of  $20 - 25^\circ$ , and then a few more rebounds through angles of a few degrees. The time between the first and second bounce was approximately .050 sec.

2. Fin operated with a 10 in-lb torque to simulate air pressure.

The fin rebounded three or four times with an amplitude of a few degrees and came to rest .008 sec. after first striking its back stop.

A design with an enclosed fin pivot is shown on Drawing No. 585220, Page 91 . This enclosure is to provide protection from dirt that might tend to prevent the fins from opening properly. Since all of the above designs had fins that were considerably shorter than those of the standard design, it was decided to develop a model with larger fins.

A design with longer fins that utilizes a fin ring similar to that on the standard rocket, is shown on Drawing No. ESO-585275, Page 92 . This model does not have the fin stability\* that was obtained in the slotted fin mounting of the previous model. The assembly shown on ESO-585272, Page 93 , possessed a long and stable fin but due to the pressure of the latch, the steep slope of the fin ring did not permit easy loading of the rocket in the launcher. Photographs 116272, Page 74 , 116273, Page 75 , and 116274, Page 76 , show views of this model. The slots in the end are due to machining a sandcasting and would not be present in production parts when made as a die-casting. ESO-585404, Page 94 , is similar to the above but contains a tapered end that permits easy loading. ESO-585432, Page 95 , is a design in which the fin ring is fastened by spinning instead of by the threaded method. This drawing also illustrates that either the Revere or Budd rockets may be adapted for cowlings. A tail assembly in which both the cowl and the fin ring at the throat are streamlined is shown on ESO-585993, Page 96 , for a Budd rocket and ESO-586034, Page 97 , for a Revere rocket. The longer throat provides an added thrust to the rocket. Photographs 119349, Page 77 , and 119350, Page 78 , show views of this type cowl on a Budd rocket.

A method of providing fixed fins in addition to the folding fins is shown on Drawing No. ESO-585916, Page 98 . The end of the fixed fin is formed to provide a hinge and

\*The fin stability desired is the resistance of the fin in its open position to any wobble about its long axis.

protection for the folding fin in its closed position. A simplified design that eliminates slots and air pockets is shown on ESA-585980, Page 99. ESO-585949, Page 100, is a similar arrangement except the fixed fins are midway between the folding fins. This provides better support for the fin retainer but does not protect the fins as well as the previous assembly. ESA-585986, Page 101, is a modification of the above design which eliminates the slots and air pockets.

ESA-585981, Page 102, is a more streamlined assembly but contains slots for the folding fins. One of the first designs with fixed fins is shown in Photograph 108519, Page 79, (a latch groove was not included in this model).

A cross piece was attached to each fin in order to provide additional fin area to the standard Revere fin assembly as shown on Photographs 124362, Page 80, and 124363, Page 81.

All of the designs discussed so far have fins that assume a radial position when fully opened and have a short bearing length at the hinge. A "U" shaped fin with a streamlined cowling as shown on ESO-586362, Page 103, provides increased fin stability because the fin is hinged along a wide base. Views of this model are shown in photographs 121813, Page 82, and 121814, Page 84. This type fin with fixed fins instead of a streamlined cowling is shown in Photograph 123936, Page 84. The object on the right is a cover for

protecting the fins and the hinge from dirt or damage. This cover is shown in place in photograph 123935, Page 86 . The fixed fins provide a hinge for the "U" shaped fins and protection for them in the folded position, as shown in photograph 123937, Page 85, 30-260666, Page 87, is an assembly drawing of this model.

#### CONCLUSIONS

The final tail end designs selected for wind tunnel tests were classified as follows:

1. Radial fins with streamlined cowling  
(ESO-585993, Page 96 )
2. Radial fins with fixed fin cowling  
(ESO-585949, Page 100)
3. "U" shaped fins with streamlined cowling  
(ESO-585362, Page 103)
4. "U" shaped fins with fixed fin cowling  
(ESO-260666, Page 87 )
5. Standard Revere fins with cross pieces  
(Photo. 124363, Page 81)

Models of the above designs were sent to the N.D.R.C. Washington, D. C. where they were tested in a wind tunnel by the National Bureau of Standards. Results of these tests are shown in ES-261357, Page 104, together with a test of the Standard Revere Rocket. The curves indicate the following:



- A. The cross pieces added to the Standard Revere fins increase the stability with a slight increase in drag. Since this model was made from a flange with loose fins a further increase in stability might be obtained if a flange with self-locking fins were used.
- B. Streamlining the tail end produces a rocket with appreciably less drag than the Standard Revere but unfortunately this is at the expense of stability.
- C. A cowl with fixed fins instead of a streamline cowl produces greater stability with only a slight increase in drag.
- D. The "U" shaped fins stabilize the rocket better than radial fins, but have a little more drag.
- E. The only model having better stability and lower drag than the Standard Revere is the "U" shaped fins with the fixed fin cowl. A further increase in stability of this model is obtained by the addition of cross pieces shown in Photograph 123936, Page 84. The drag with these pieces added is the same as without them.

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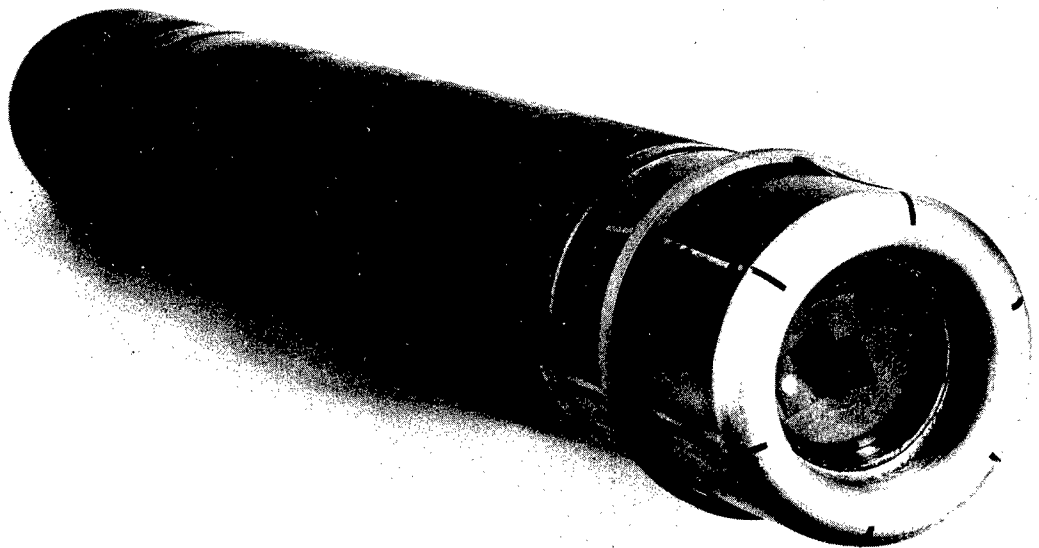
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116272

BUDD ROCKET WITH COWLING SHOWING FINS IN FOLDED POSITION

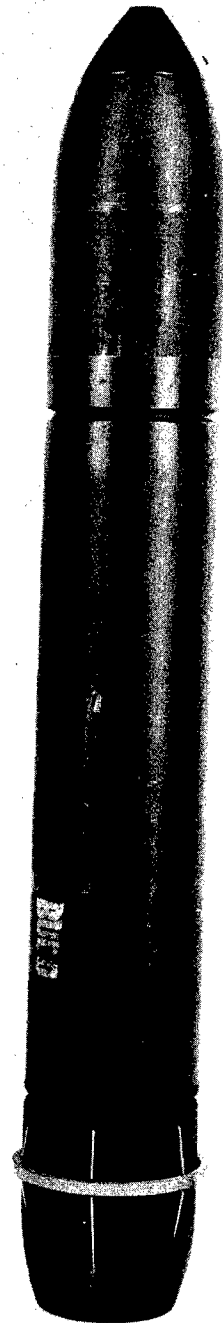


116273

BUDD ROCKET END VIEW - SHOWING SEALING DISC



BUDD ROCKET SHOWING FINS EXTENDED



119349

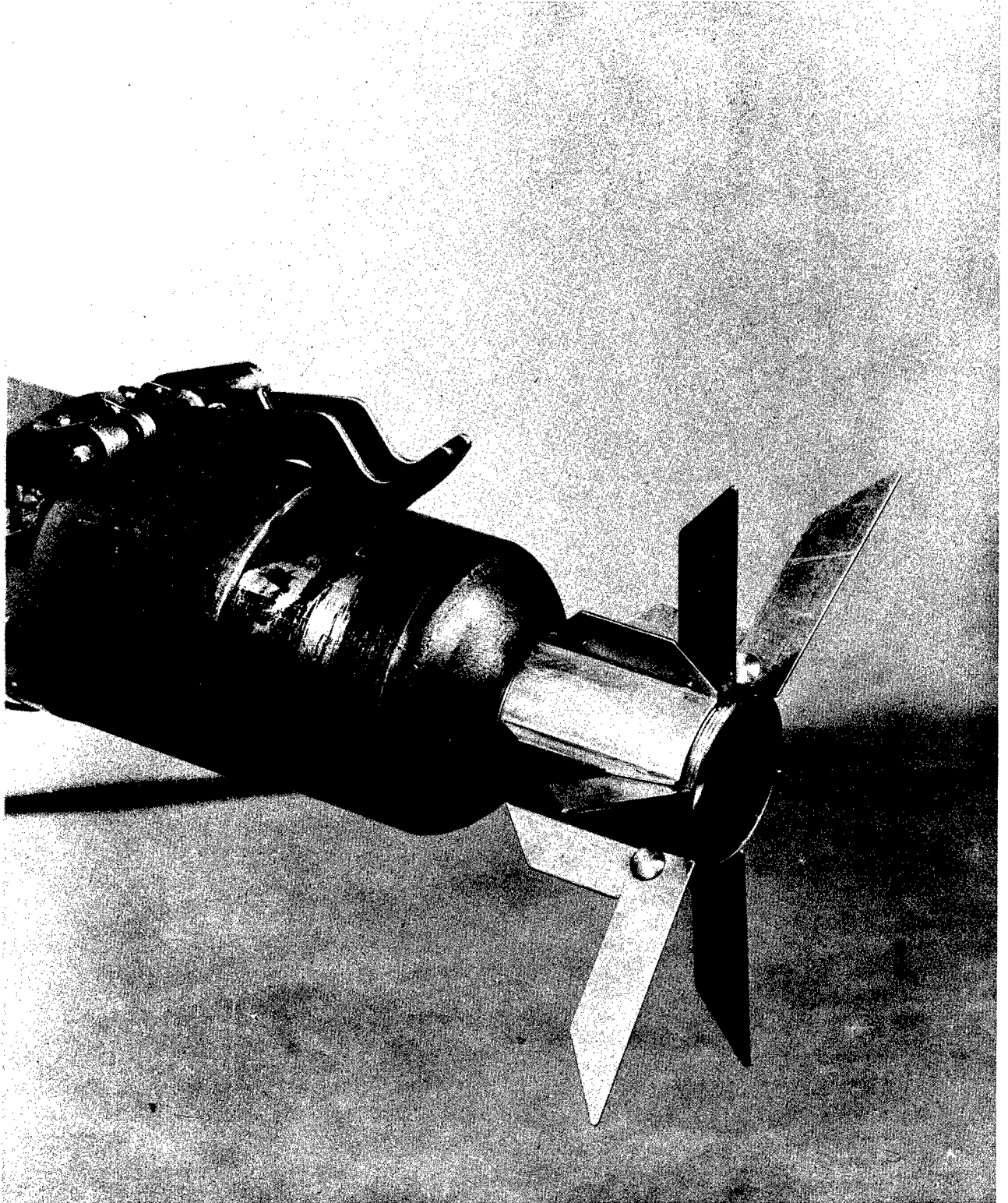
BUDD ROCKET - STREAMLINED COWLING WITH FINS IN CLOSED POSITION





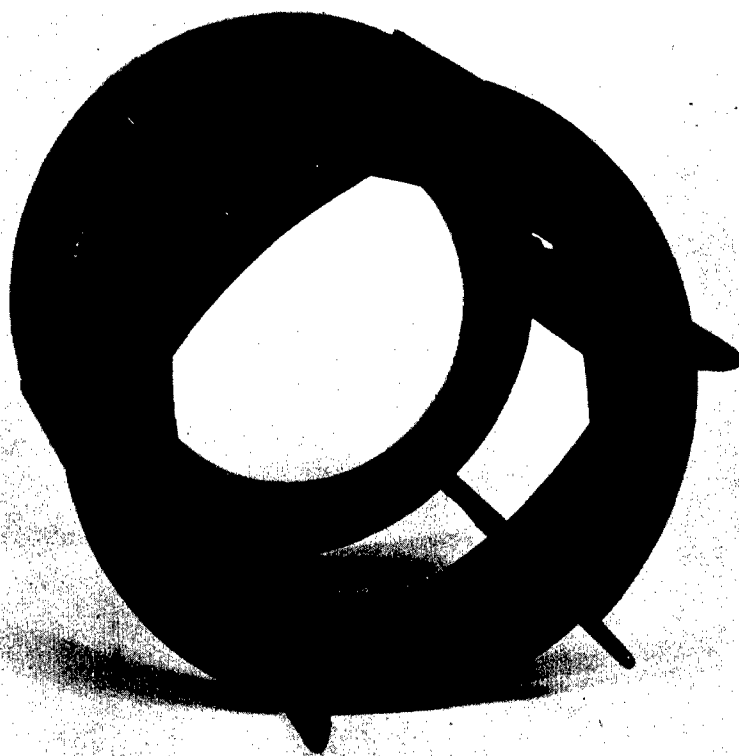
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BUDD ROCKET - STREAMLINED COWLING WITH FINS IN OPEN POSITION



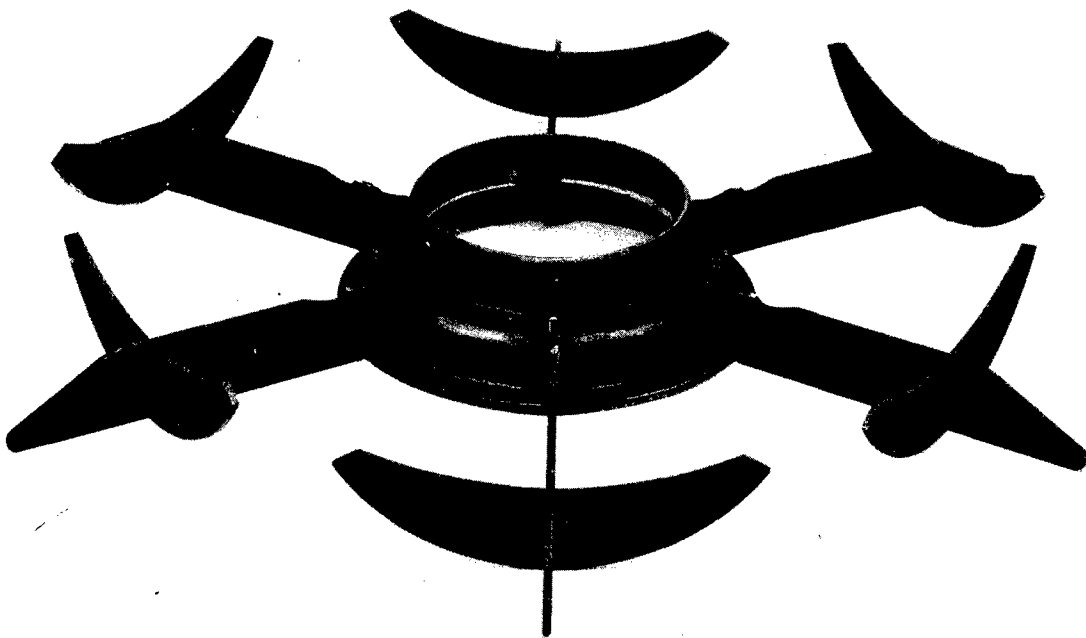
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ROCKETS WITH FIXED AND FOLDING FINS



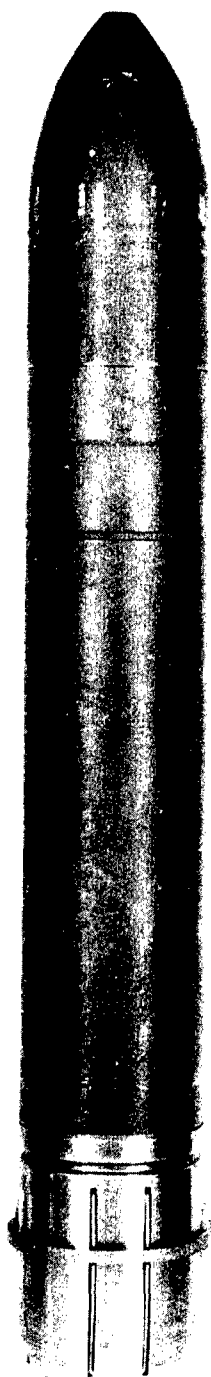
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REVERE FIN ASSEMBLY WITH CROSS PIECES IN FOLDED POSITION



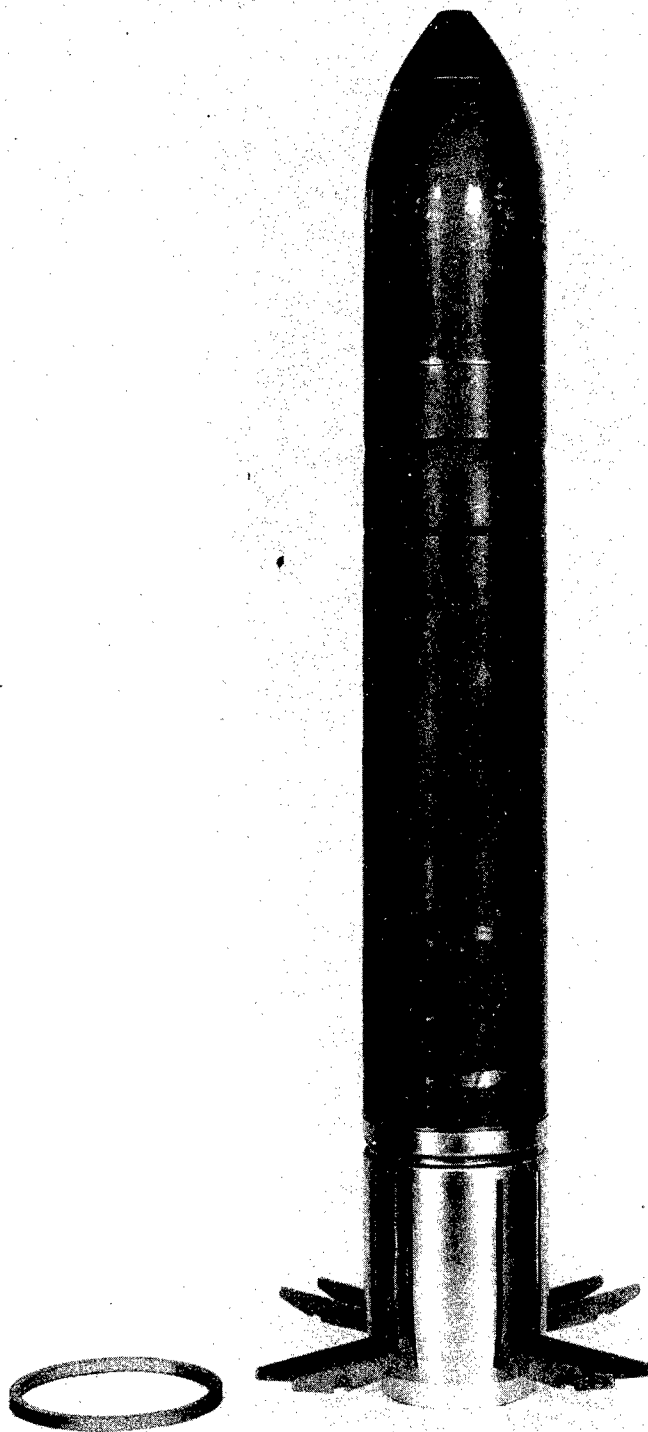
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REVERE FIN ASSEMBLY IN OPEN POSITION



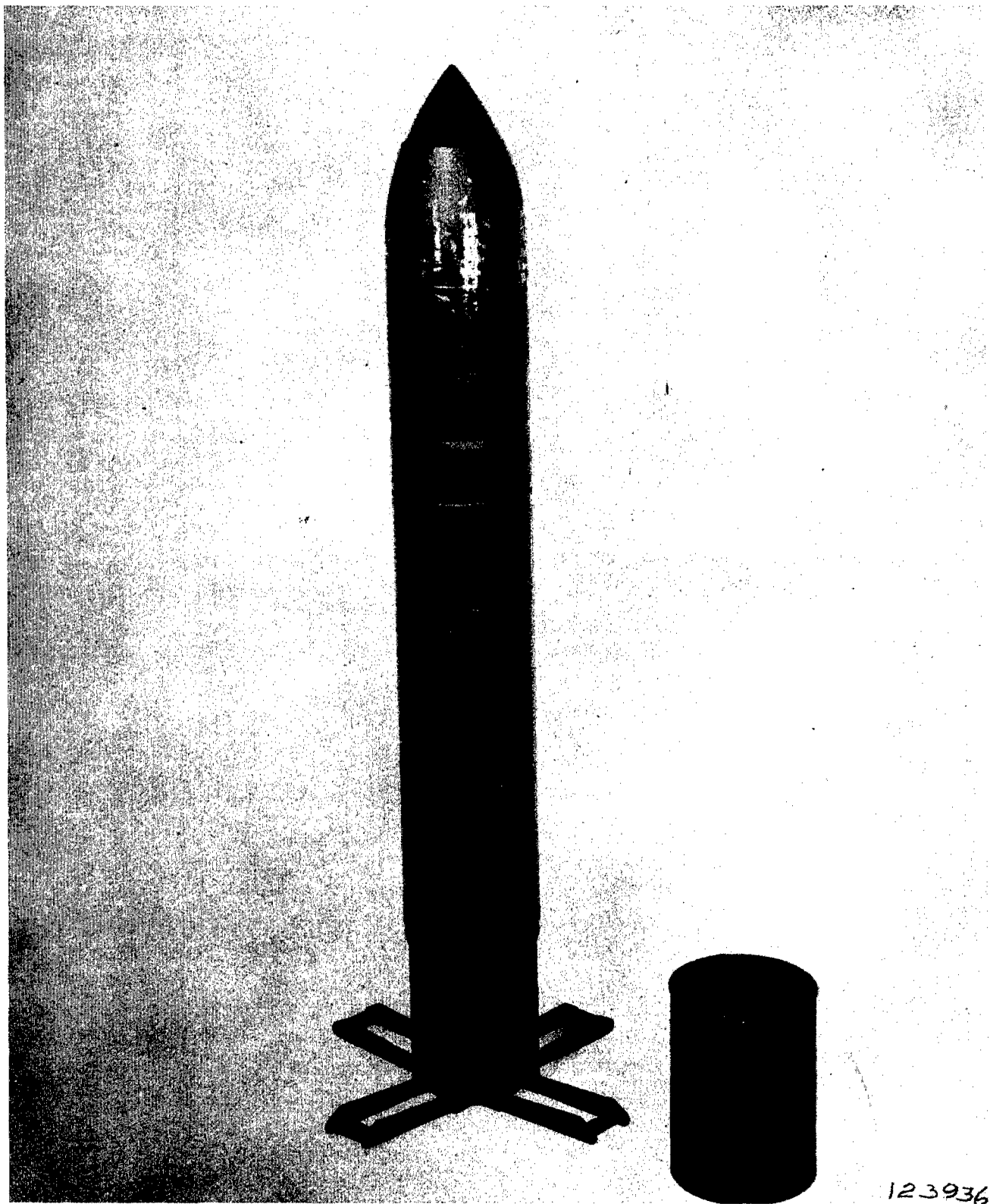
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ROCKET EQUIPPED WITH STREAMLINED COWLING AND "U" SHAPED FINS, FOLDED

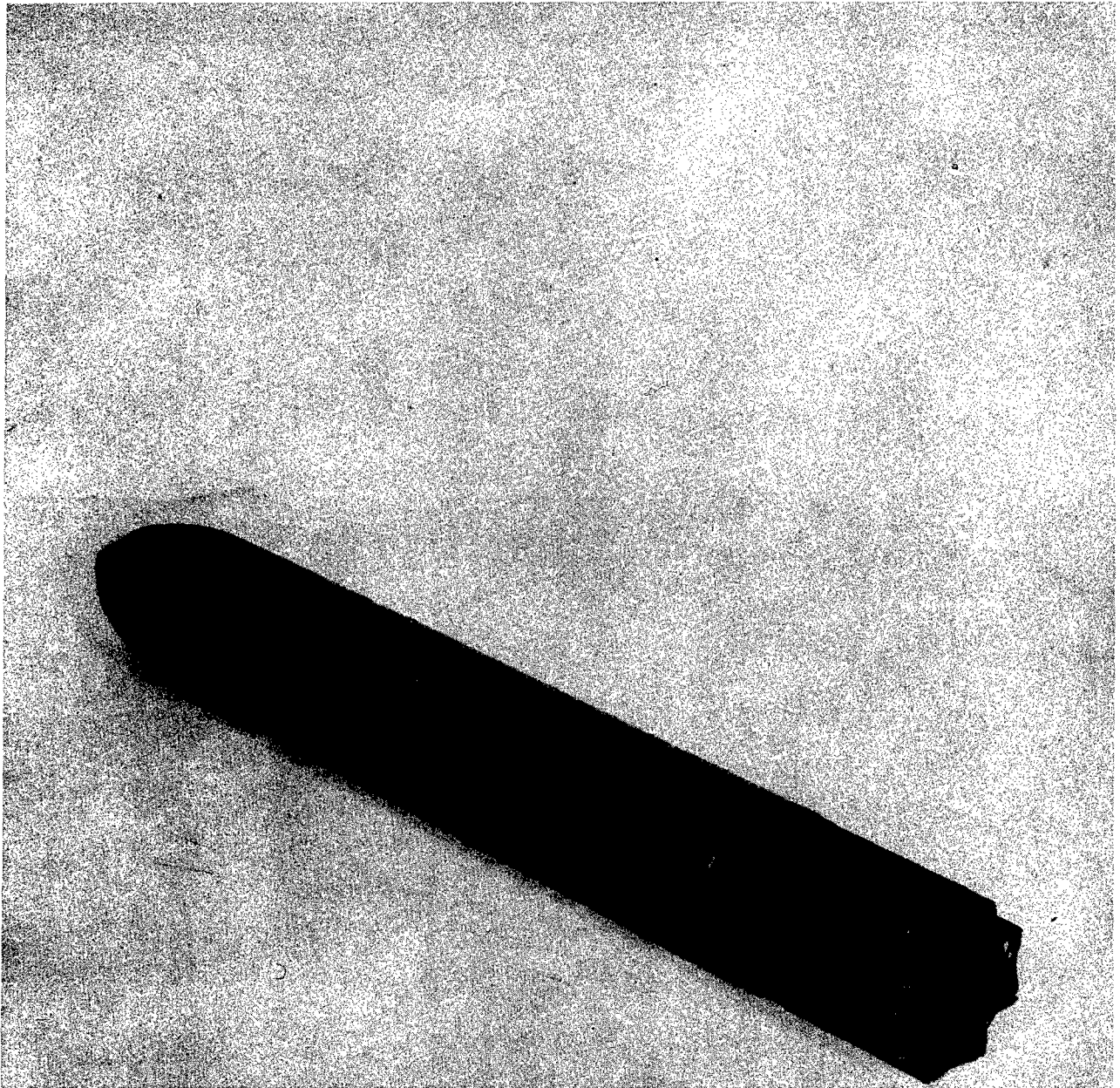


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ROCKET EQUIPPED WITH STREAMLINED COWLING AND "U" SHAPED FINS, OPENED



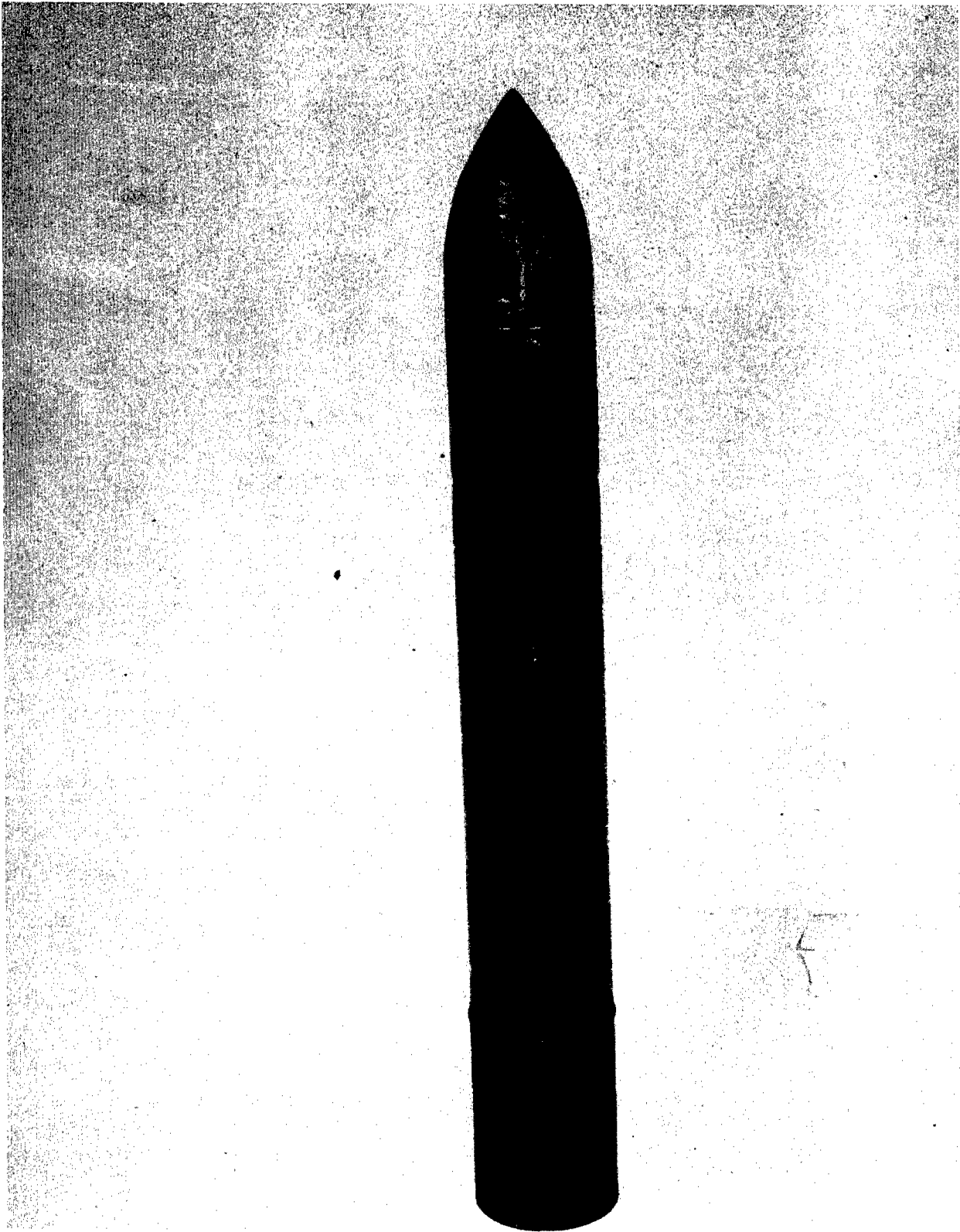
"U" SHAPED FINS WITH FIXED FIN COWLING, OPENED



123937

"U" SHAPED FINS WITH FIXED FIN COWLING, CLOSED

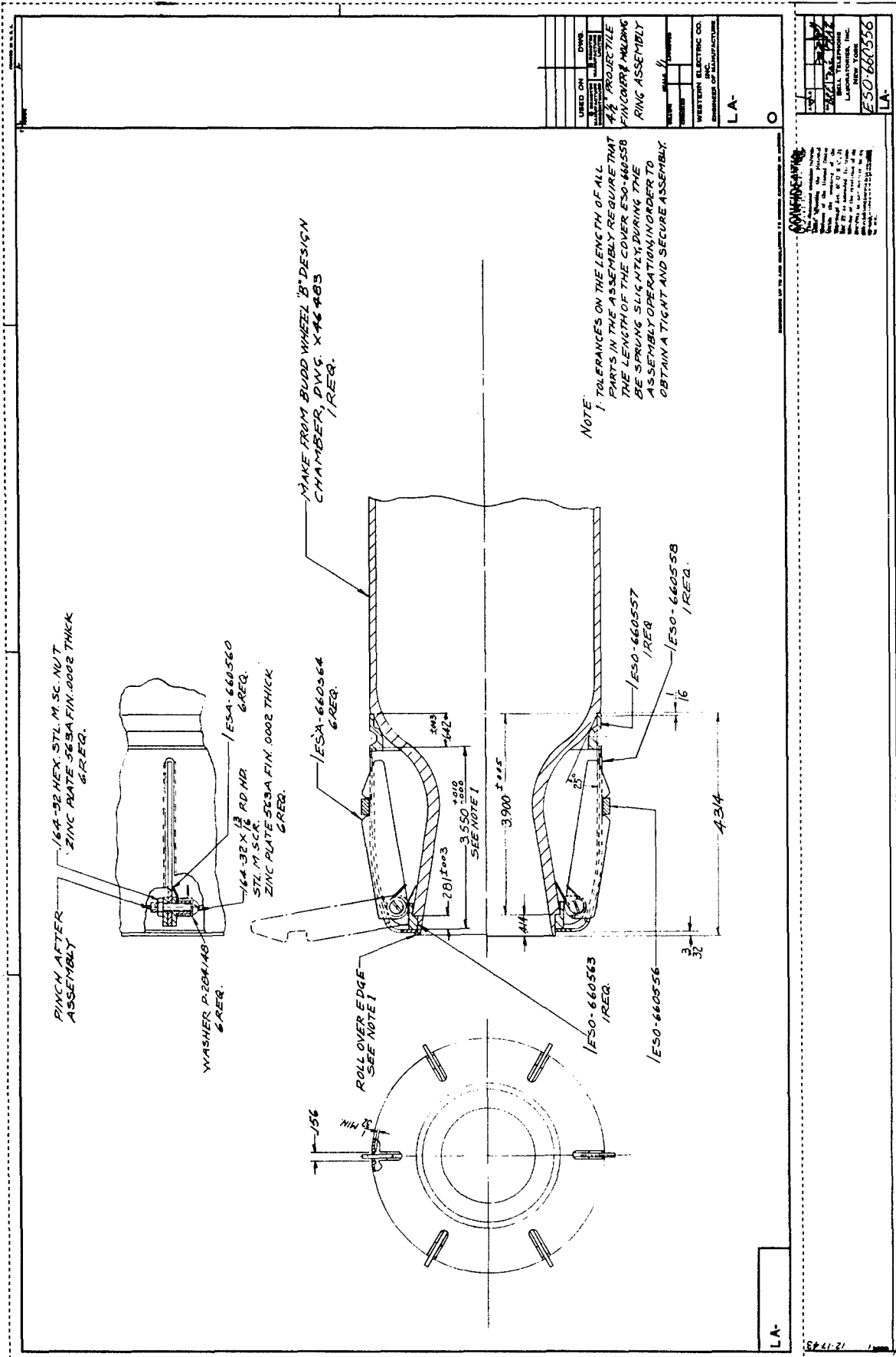




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"U" SHAPED FINS WITH FIXED FIN COWLING COVER IN PLACE





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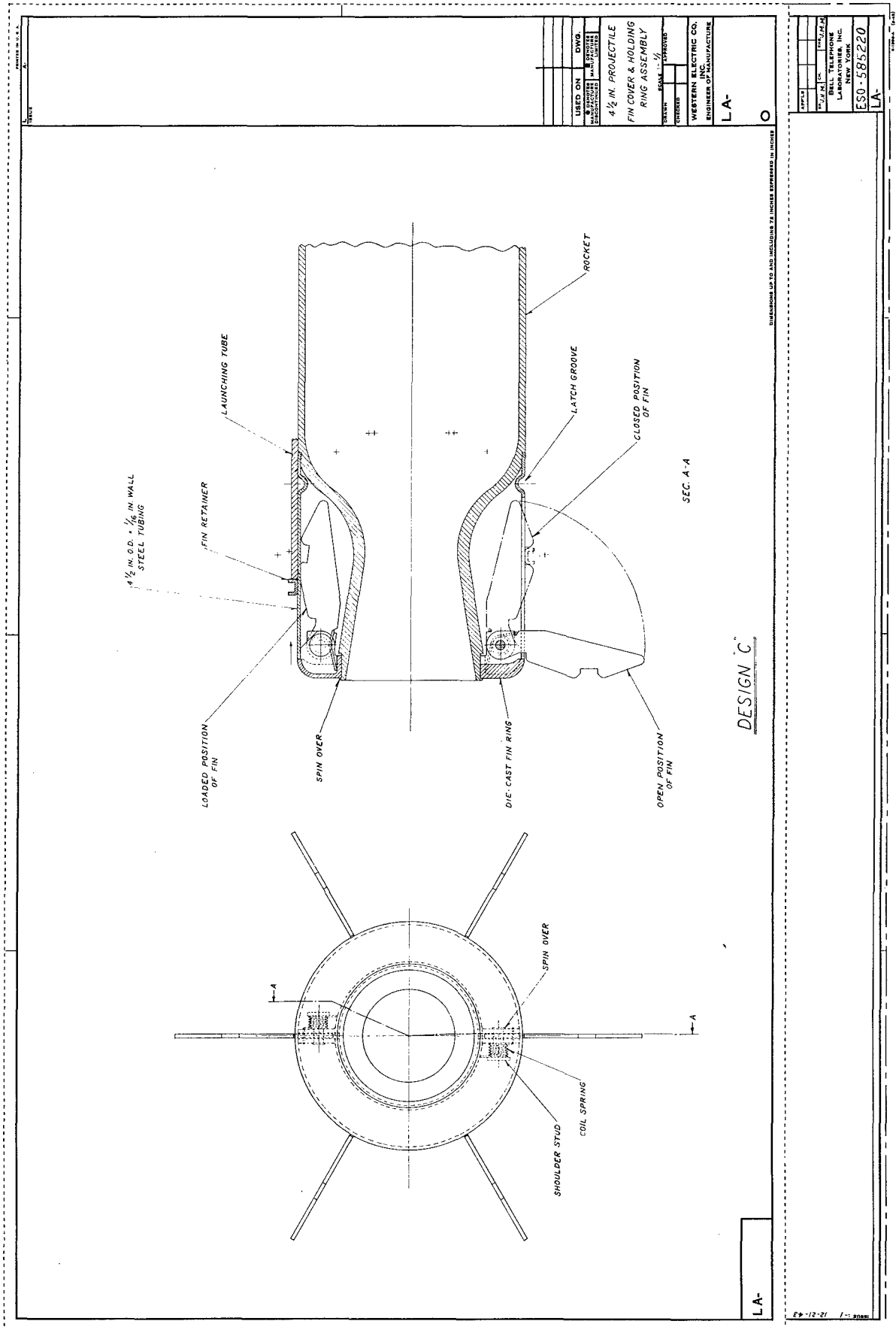



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NEW YORK

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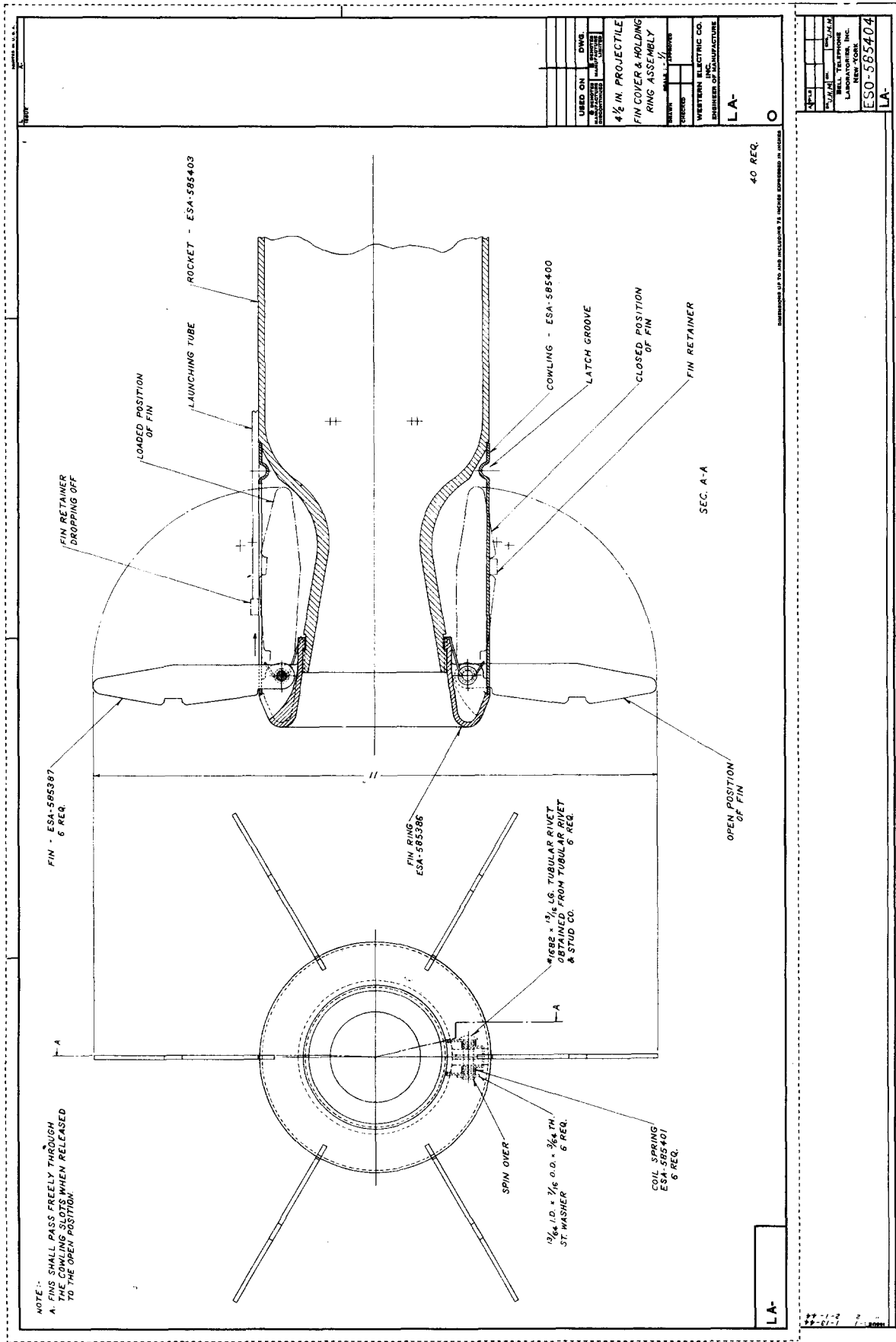
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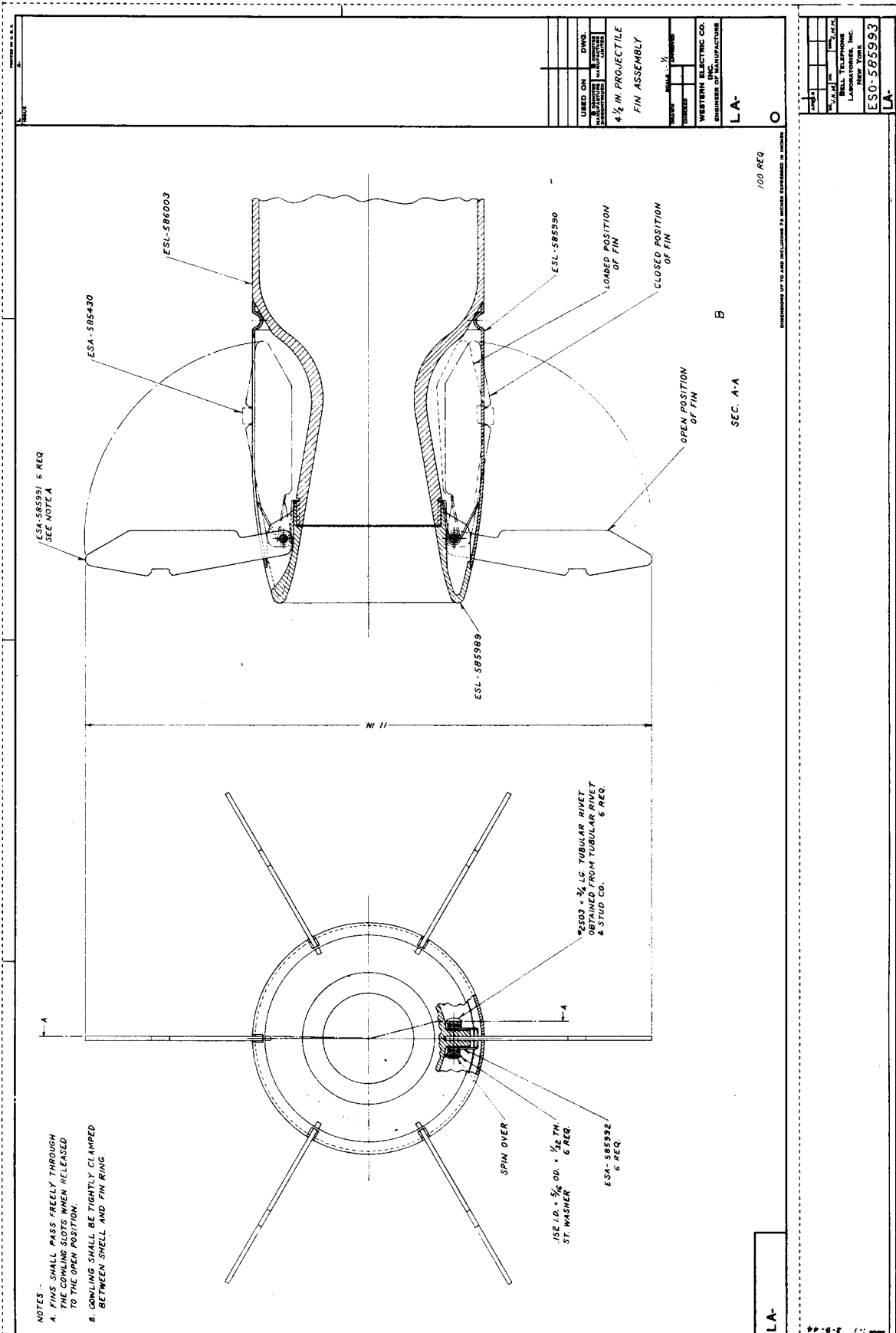


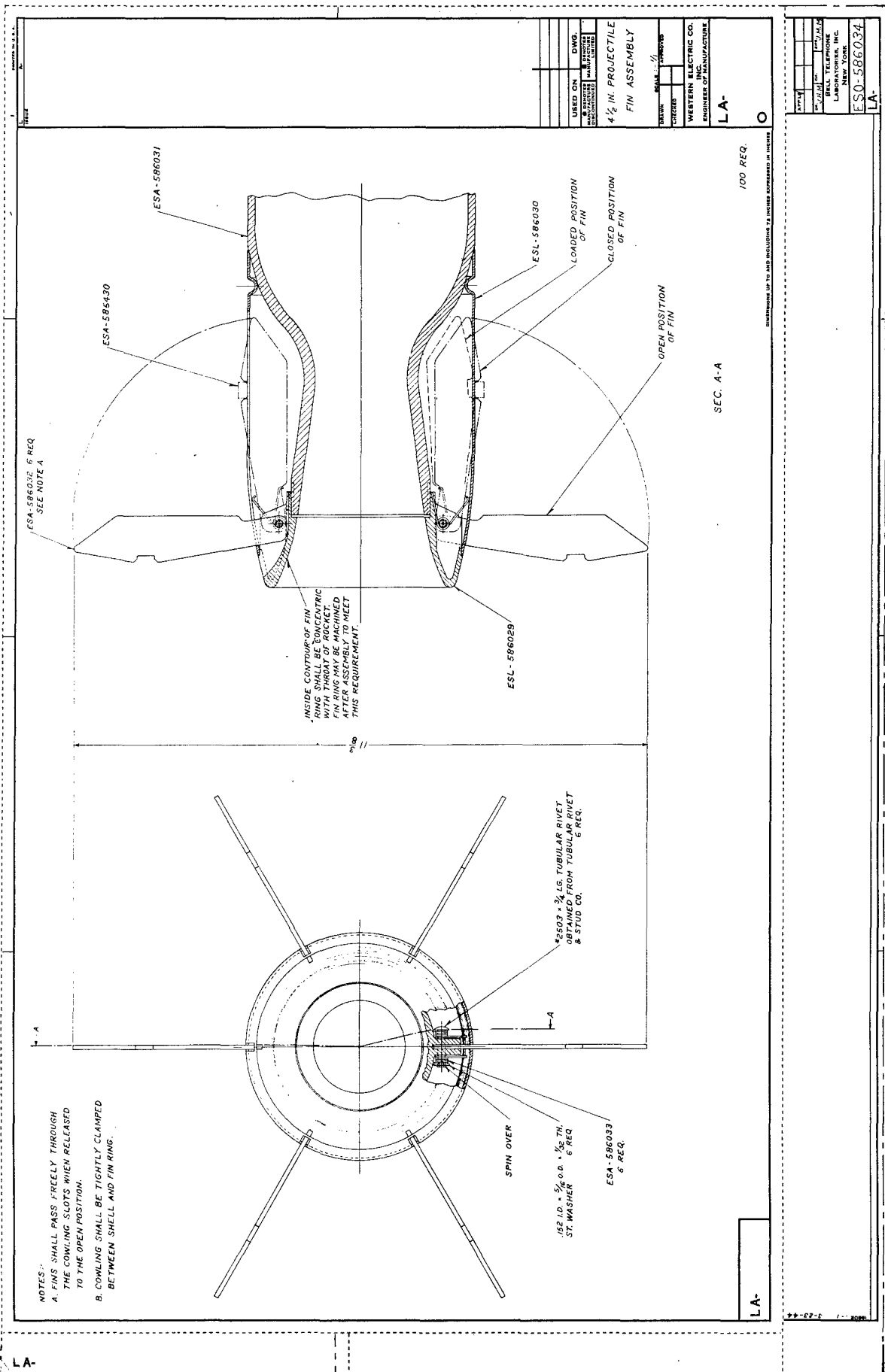


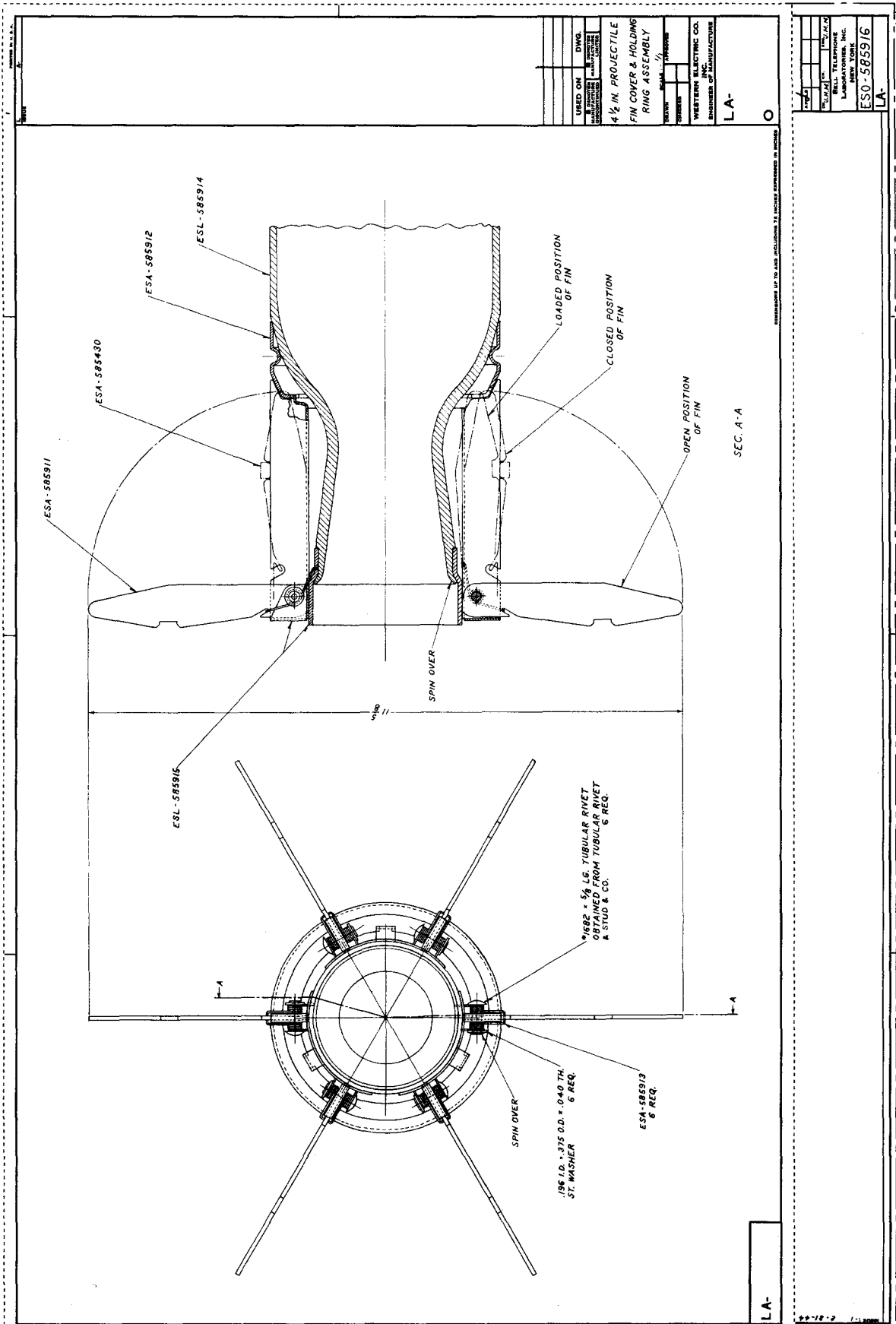


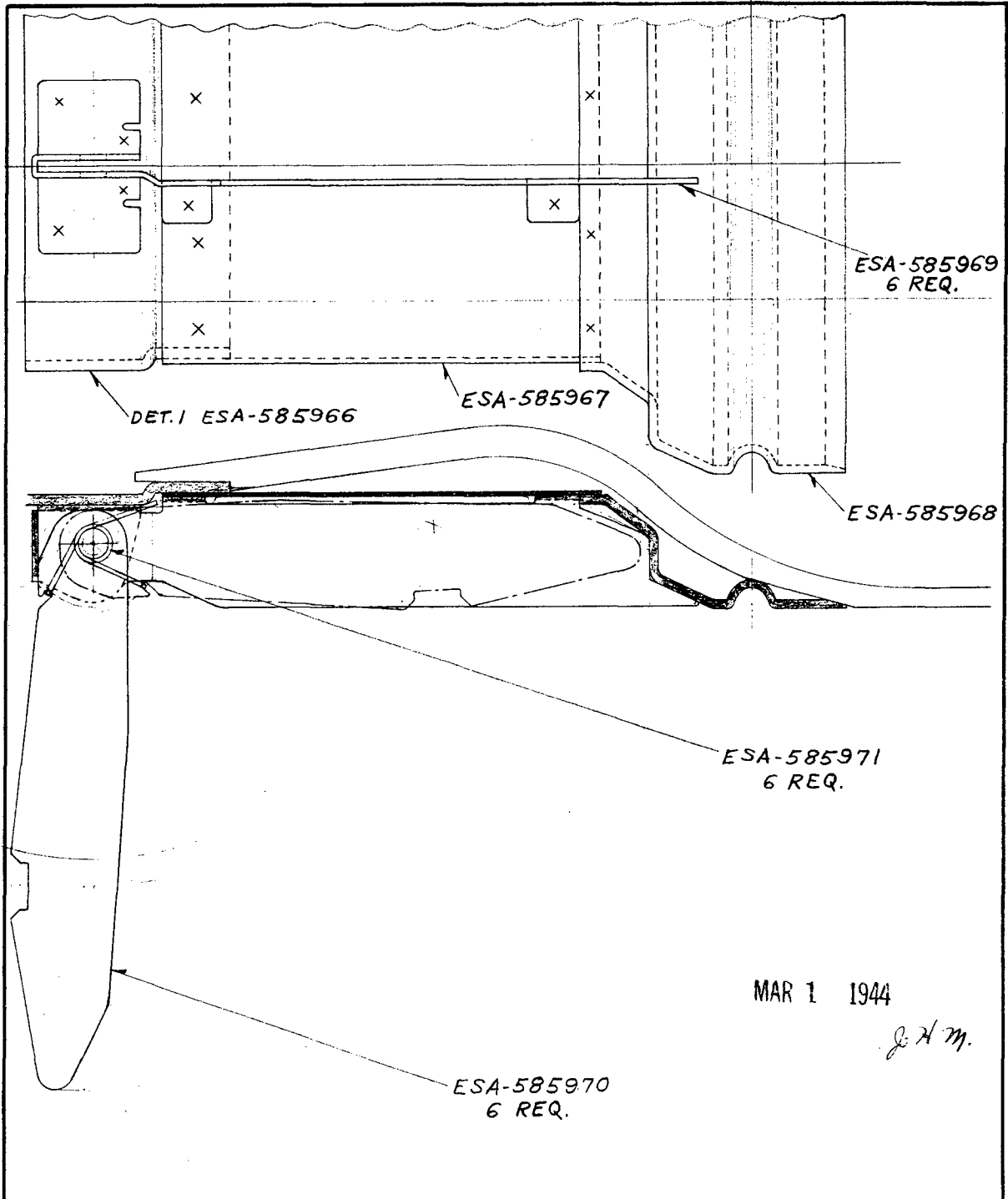












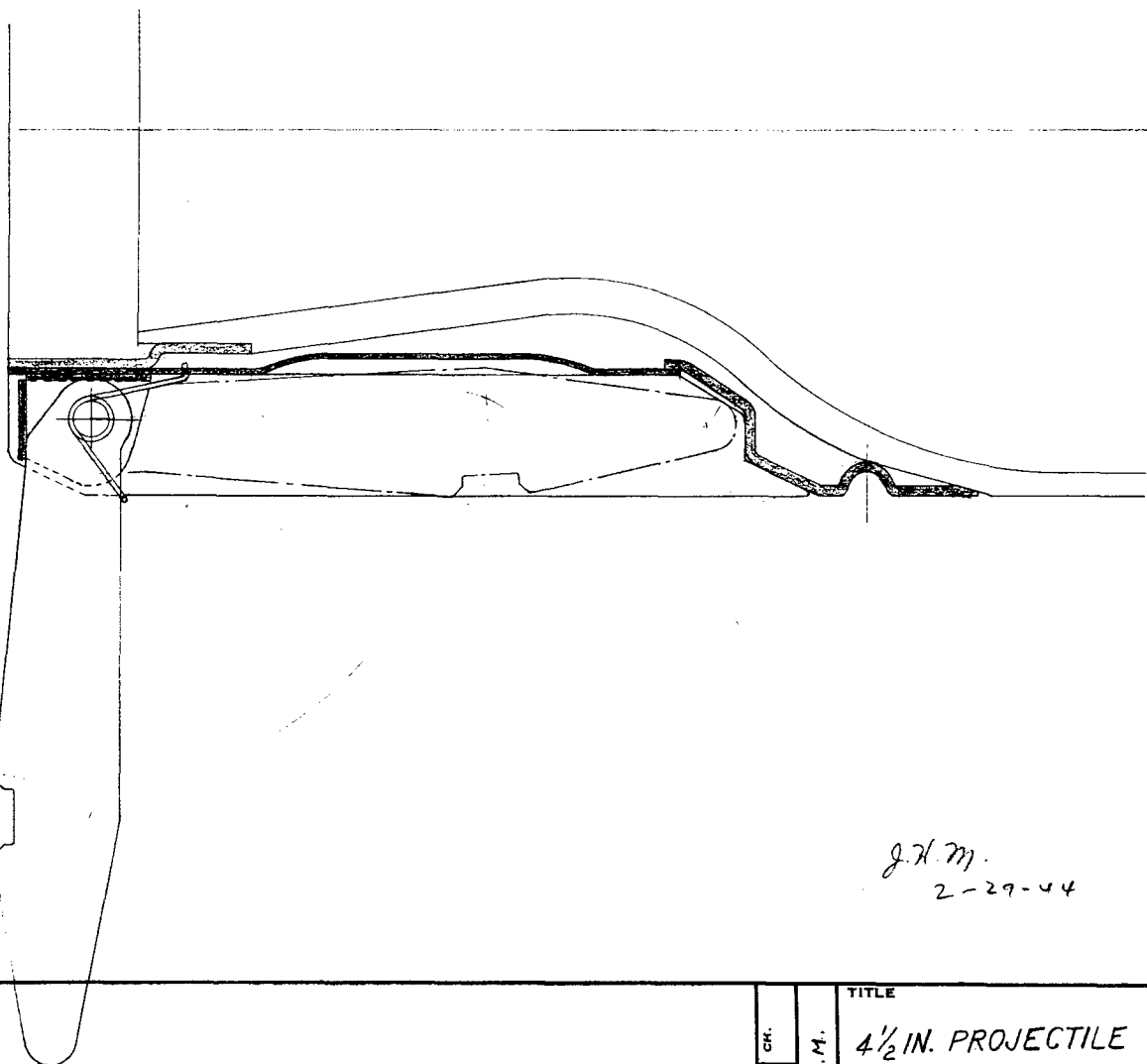
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DR. J.H.M.  
CH.  
ENG.

TITLE  
4 1/2 IN. PROJECTILE  
FIN ASSEMBLY  
SCALE 1-1/1  
BELL TELEPHONE LABORATORIES, INC., NEW YORK  
ESA-585980



OTHERWISE SAME AS ES0-585949

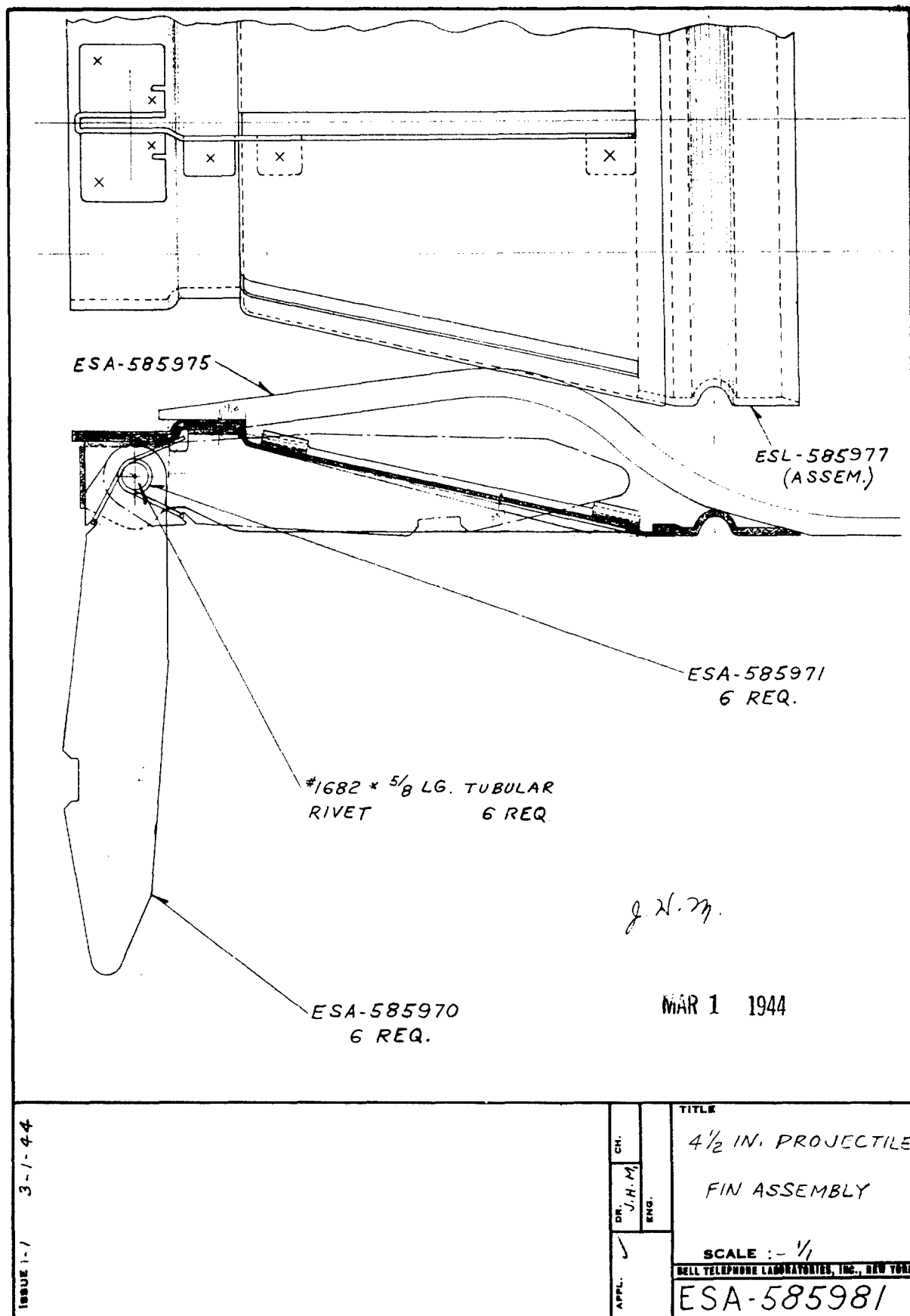


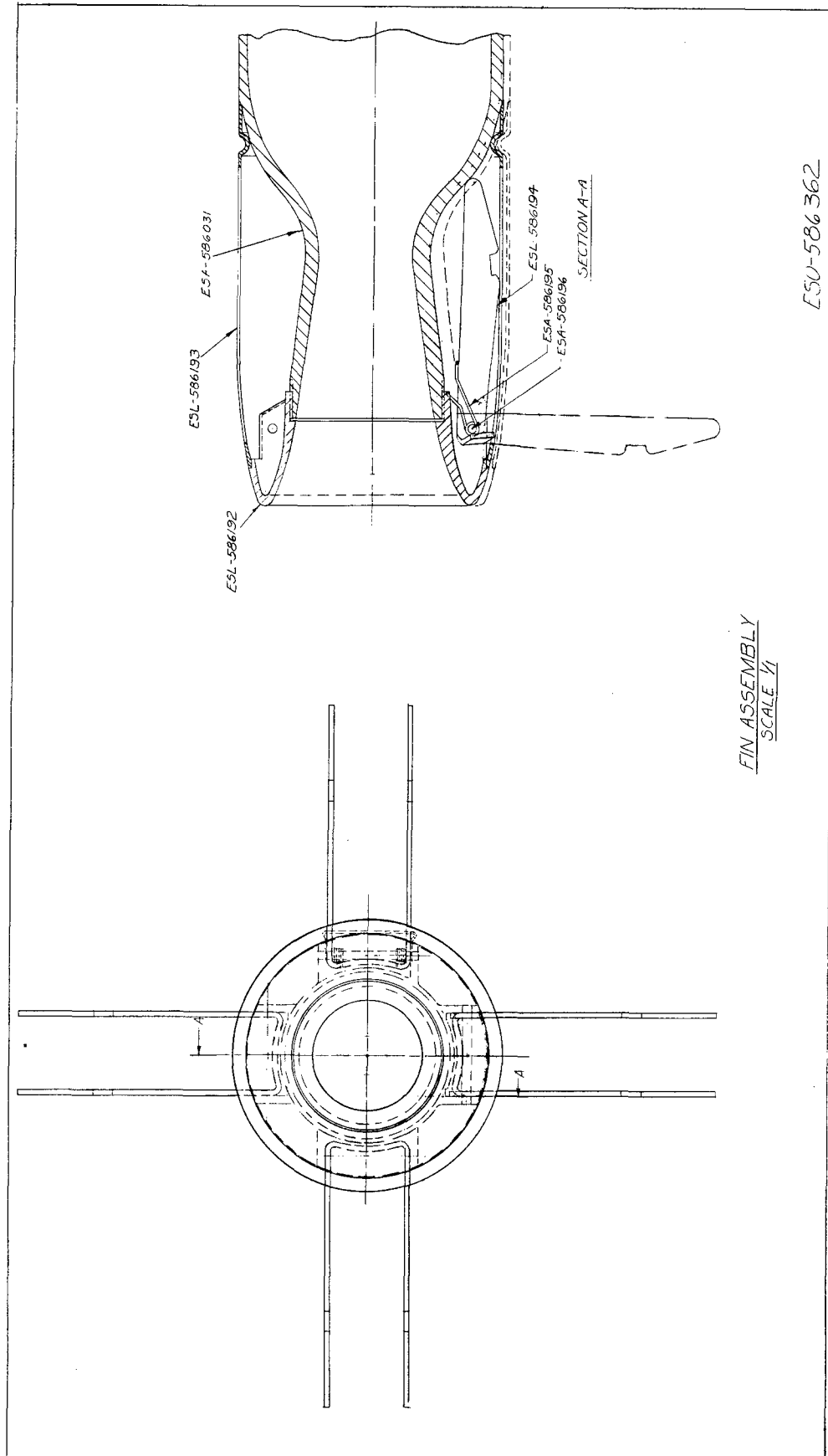
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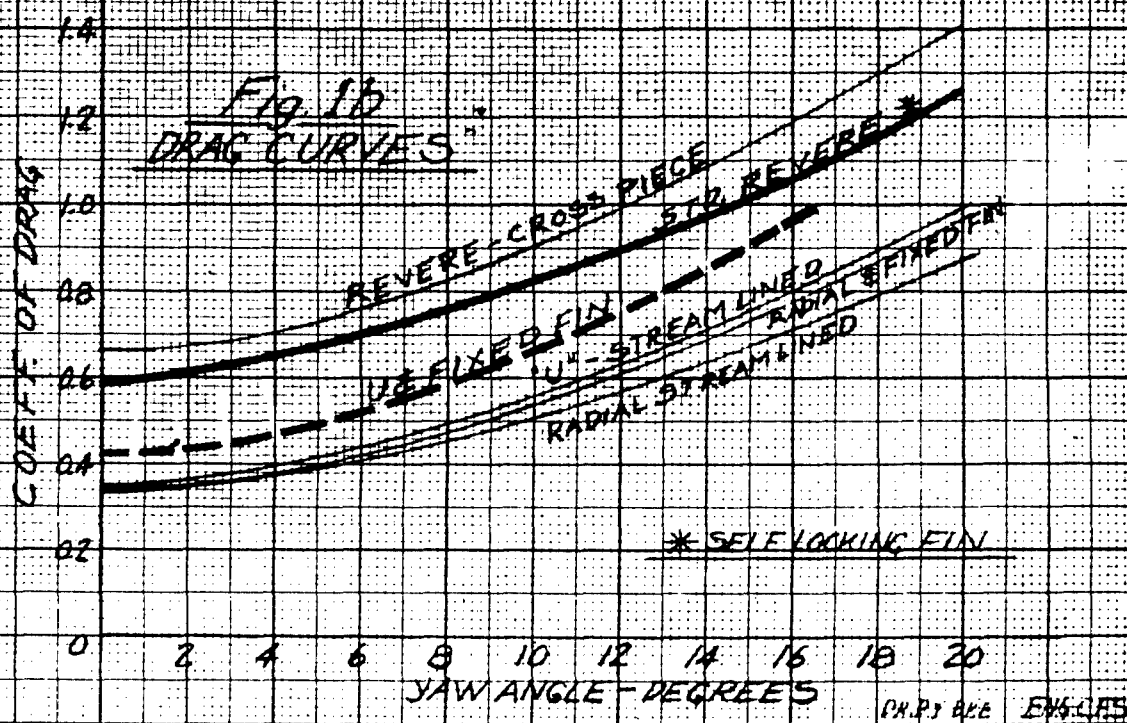
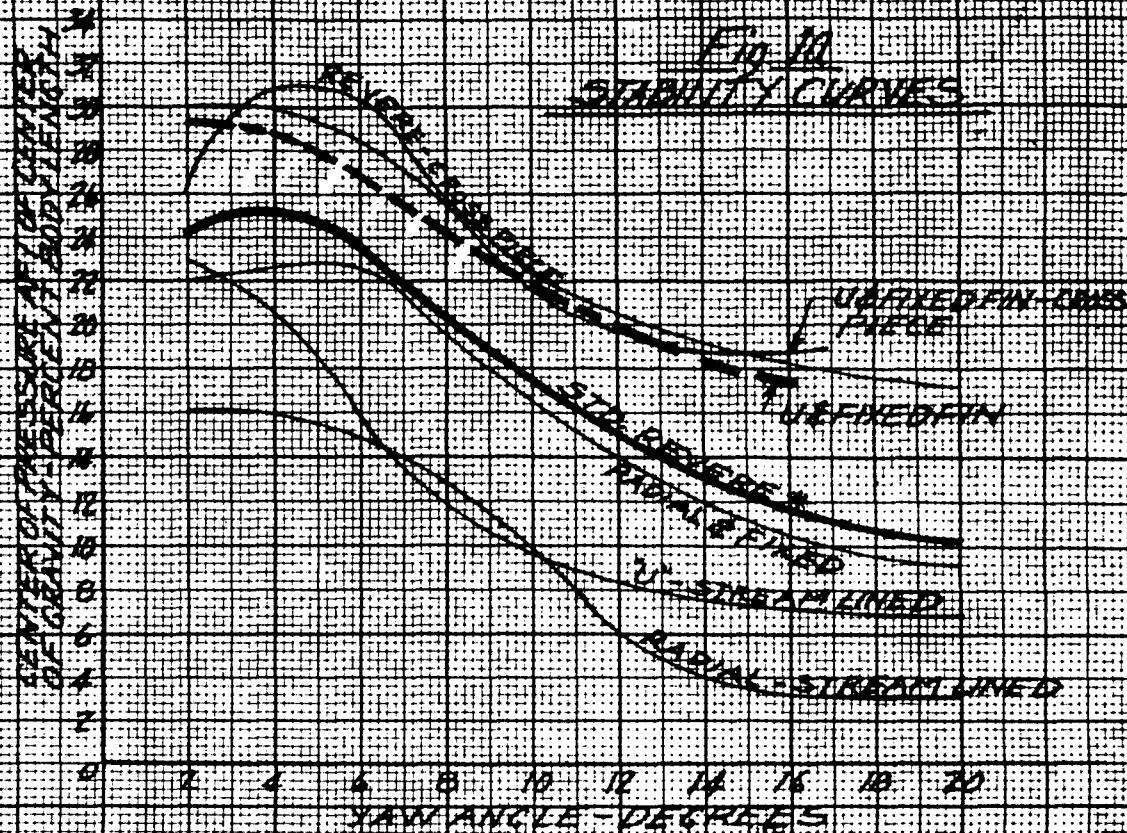
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APPL. ✓	ENG. J.M.M.	
SCALE : - 1/1		BELL TELEPHONE LABORATORIES, INC., NEW YORK
ESA-585986		







ES-261357



PART V  
IGNITION SYSTEM

INTRODUCTION

Engineers at the Jet Propulsion Research Laboratory, Indian Head, Md. proposed a long thin type igniter for use in the 4-1/2 inch rocket which could be inserted through the nozzle and which was attached to the closure cup. Section H of NDRC requested the Bell Telephone Laboratories to design the igniter, closure cup and contacting plug for production. The igniter was made thin and narrow so that it could be inserted between the powder sticks and the buster tube. It was made long so that ignition could be started throughout the length of the rocket and thus reduce the ignition time and eliminate hangfires. The long ignition time and hangfires were seriously interfering with the hits made by pilots because after firing, the pilot would start to pull out of his course before the rocket actually left the launcher. Plug and jack type connectors were proposed in order to eliminate the poor contacts obtained with the G. E. system.

DESCRIPTION OF IGNITER

The contacting system that was to be improved is shown in photograph 147615, page 114. The electrical connection was made by the two fingers attached to the launcher with the two concentric rings of the igniter. The igniter is shown in photograph 147618, page 117. The squib is wired to the concentric rings and is inside the cylindrical tube which contains the black powder.

The Laboratories proposed that a more reliable electrical connection could be made by using a telephone plug and jack. NDRC had suggested putting the black powder in a long plastic envelope in order to insert it through the nozzle and place it in closer proximity to the propellant powder.

A drawing of the bayonet type igniter assembly that was developed, is shown on photograph 147619, Page 118. The igniter tube 2 containing the black powder 15 and the squib 1, is cemented to the igniter cup 7. The telephone plug 10 is wired to the squib 1 and is held in the cup by two fuse clips 12, attached to the sealing disc 14. The fuse clips 12 are electrically connected by the shorting bar 13. Thus the squib is electrically short circuited while the plug is in the cup. The sealing disc 14 is held in place by the cotter pins 8. A picture of the bayonet igniter is shown on photograph 147617, Page 116 and photograph 147616, Page 115, shows a section through a rocket with the igniter in place. After the rocket is loaded in the launching tube, the telephone plug is removed from the cup by pulling the sealing disc handle. The plug is then inserted in a jack mounted on the launcher, as illustrated on drawing ESA-579362, Page 119. This drawing also shows that if a control valve is to be used it may be attached to the igniter cup by means of the igniter cup screw.

A drawing of the igniter cup is shown on ESA-579359, Page 120. A multi-cavity mold was made for this detail and 20,000

parts were made and sent to the NDRC. Previous to this, a cup was designed which held only the squib wire. A single cavity mold was made for this cup and 500 parts were made and delivered to the NDRC. The following parts were also furnished to the NDRC: 250 sealing discs as per ESA-579367, Page 121, 20,000 igniter tube cups as per ESA-585278, Page 122, 20,000 igniter tube plugs as per ESA-585279, Page 123, 20,000 igniter tubes as per ESA-585498, Page 124. The telephone plug is shown on ESA-585441, Page 125. This is a commercial two conductor plug which was modified in order to fit into the igniter cup and the tip and sleeve were gold plated in order to provide good contacting surfaces. 700 of these plugs were furnished to the NDRC.

An assembly of a mounting for a telephone jack that provides a means for holding the plug in place so that any pull on the plug wire will not disengage the plug from the jack, is shown on ESA-586126, Page 127. The telephone plug 1 is shown being held by the cover 2 which is hinged on the pin 3. The jack 5 is mounted in the box 4. The cover 2 is held in the position "B", by the spring 6 and it must be raised to the position "A" in order to insert or remove the plug. Two jack mountings are shown on photograph 115348, Page 112. The upper one has the cover and box bent to shape without welding. The lower one has the parts made of thinner material and the corners are welded together. Bottom views of the mountings are shown in photograph 115349, Page 113. Twenty of these jack mountings were sent to the NDRC.

A design for holding the same telephone plug in a 3-1/4" rocket is shown on ESL-579440, Page 126. The fuze clips are attached to the fin ring by the brackets ESA-579441 and 579442. The plug is obtained by removing the fin ring from the rocket. 500 of these assemblies were furnished to the NDRC.

#### CONCLUSIONS

The various components of the igniter which were furnished by the Bell Telephone Laboratories to the NDRC were assembled by them for field tests. The results of these tests indicated that the bayonet igniter was a very reliable means of ignition, the long hangfires were eliminated and the delay between the closing of the firing button and the firing of the rocket was decreased. It also provided a safety feature by having the squib shorted until the rocket was loaded.

The igniter as a part of the T23 kit, was used by the U. S. Army Air Corps in various theatres of operation during the war.

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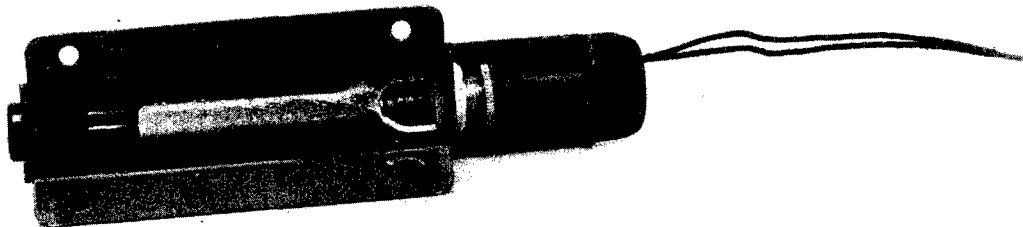
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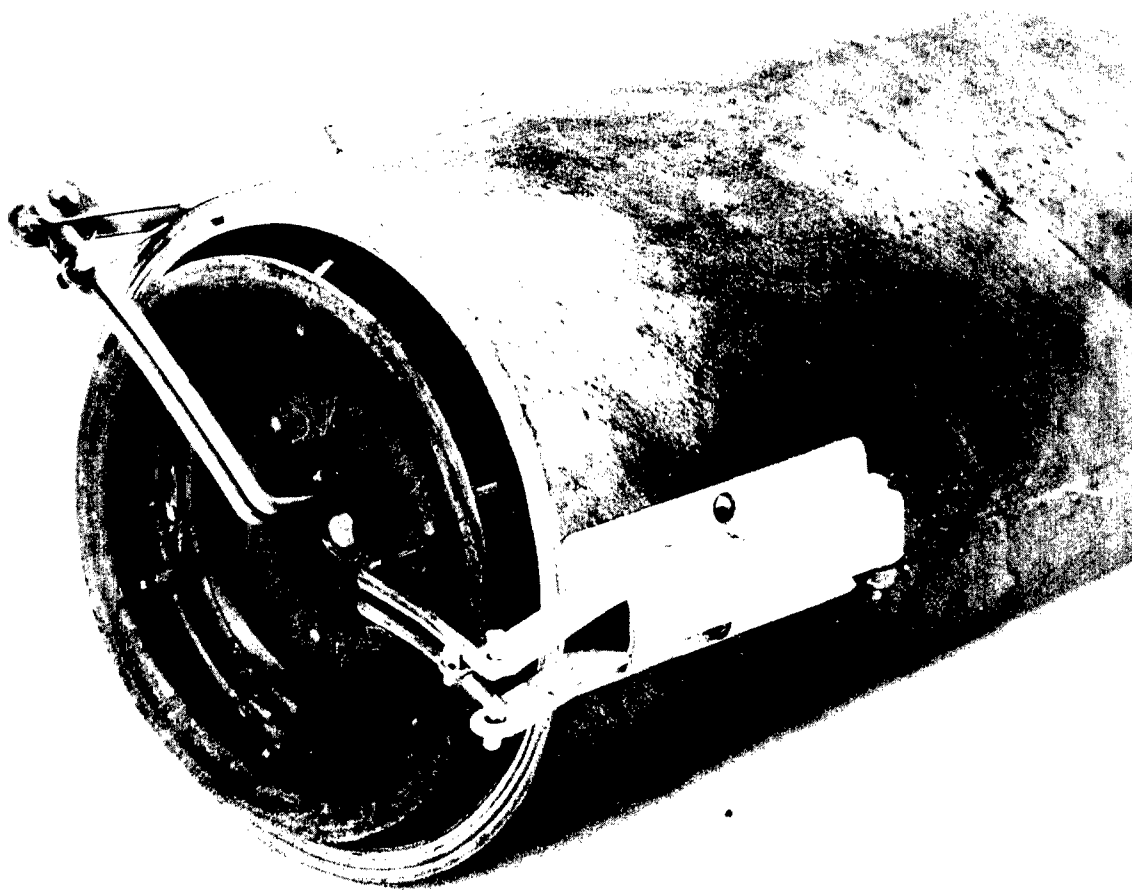
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JACK MOUNTING



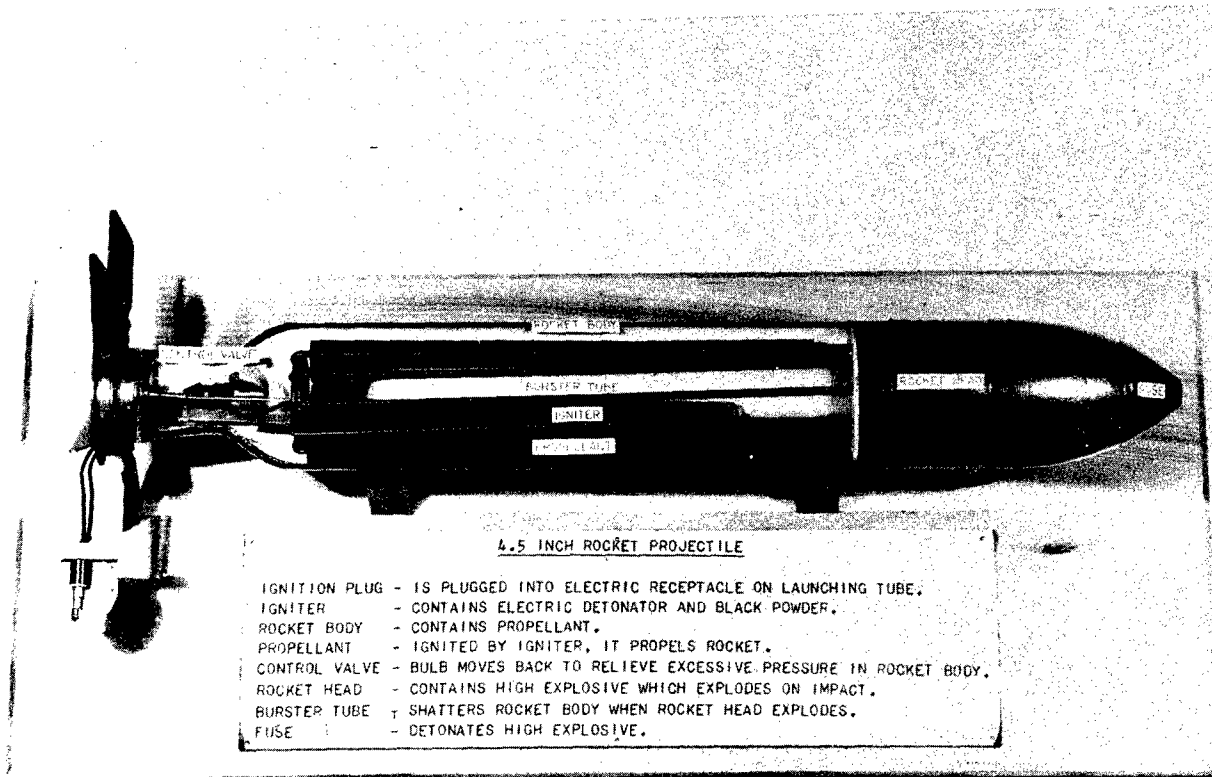
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JACK MOUNTING - BOTTOM VIEW



147615

G. E. CONTACTING SYSTEM



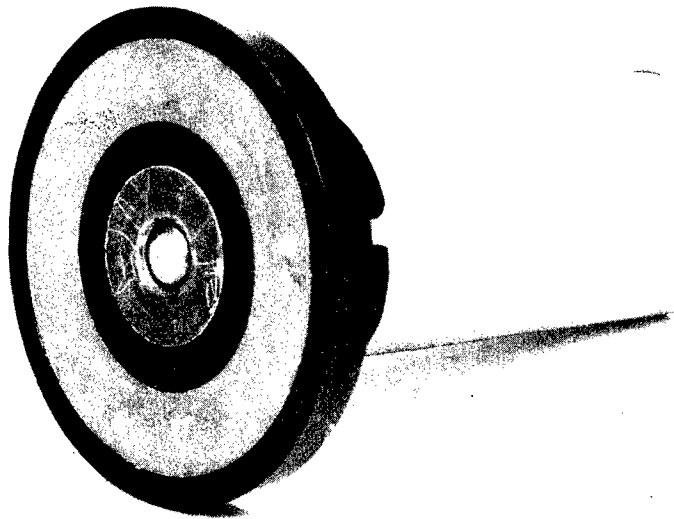
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### SECTION THROUGH 4-1/2" ROCKET



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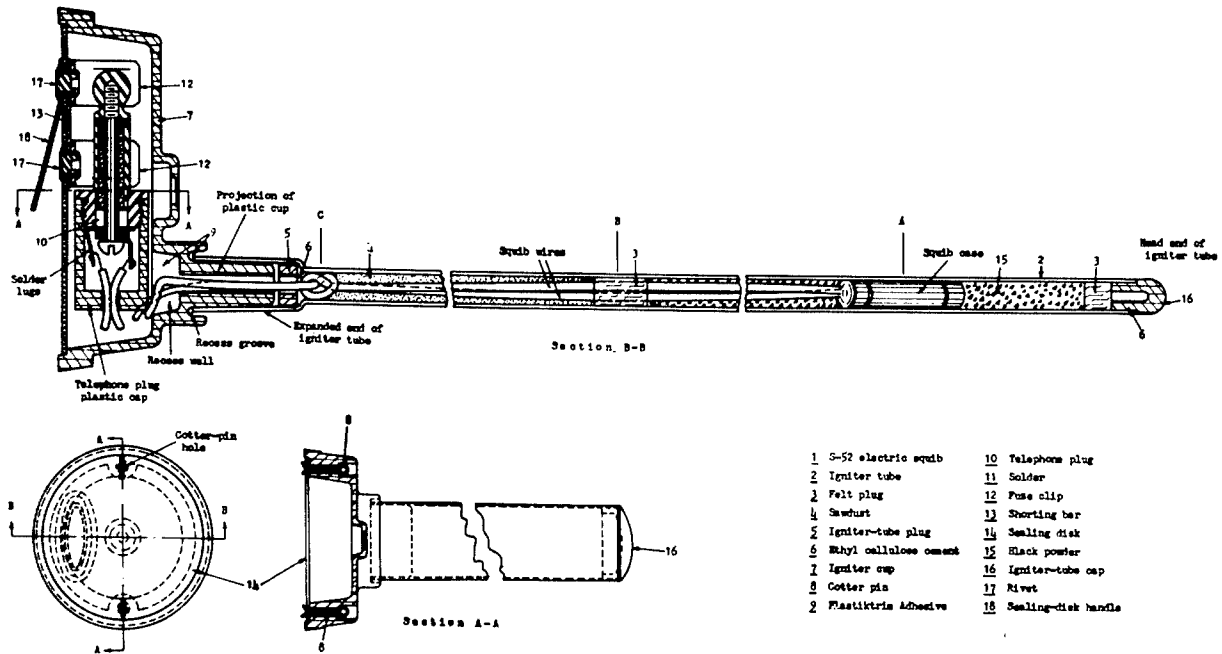
**4-1/2" BAYONET TYPE IGNITER**



147618

IGNITER





Line drawing of the 4 1/2-in. bayonet-type igniter. Section A-A shows the plastic base, igniter tube and fiber base cover, secured by cotter pins. Section B-B shows all parts of the assembly except the cotter-pin attachment of the fiber base cover.

# SECTION THROUGH 4-1/2" BAYONET TYPE IGNITER

147619

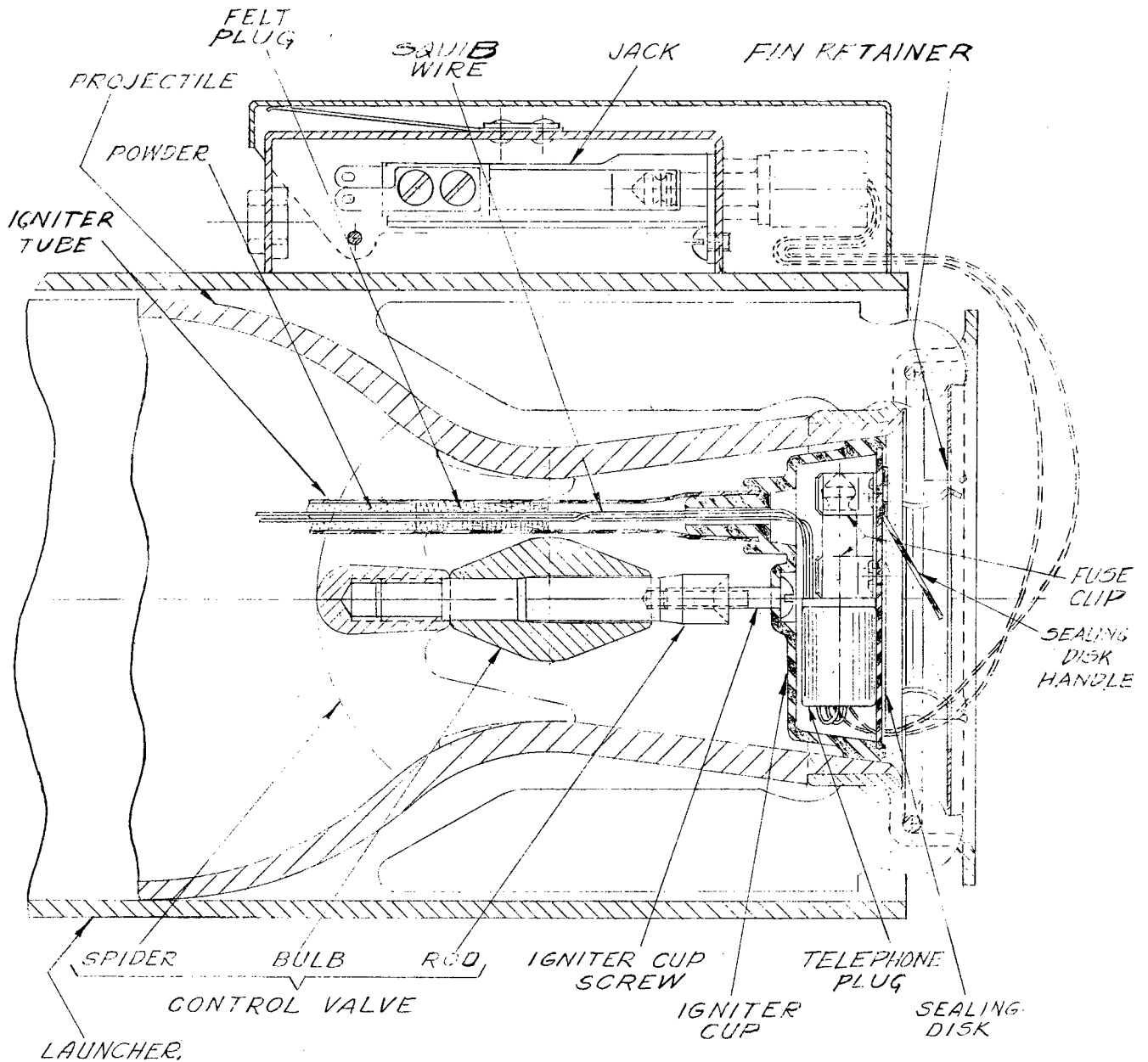
# 4 1/2 IN. DIA. REVERE ASSEMBLY

SCALE 1/4"

12-1-43

ENG. C.F.S.

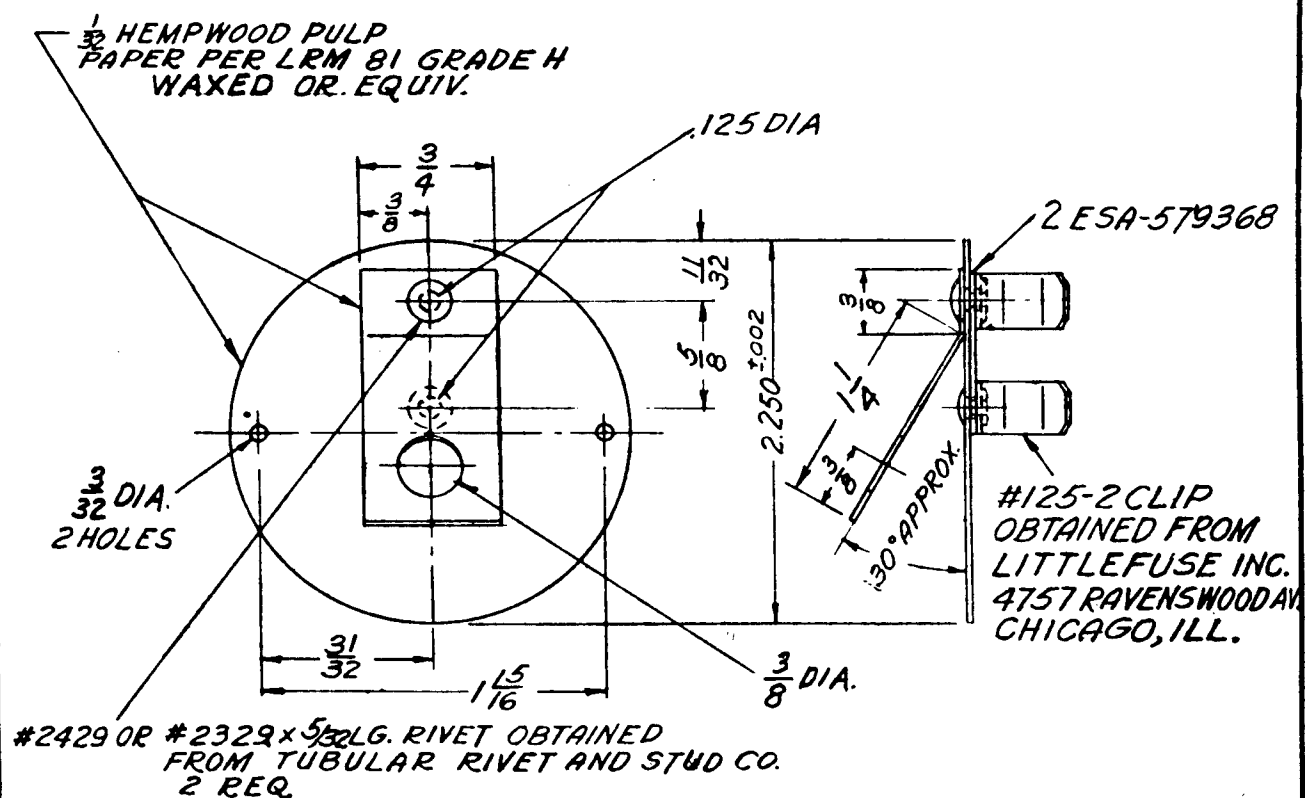
DR. W.J.S



ESA-579362

PHENOL PLASTIC  
BAKELITE BM 020  
OR EQUIVALENT.

ESA-579359



1 REQ 1A

ISSUE 1	11-26-43
2	12 17-43
3	1-18-44
4	3-29-44

APPL.	DR. <i>WJS.</i>	CM.
	ENG. <i>C.F.S.</i>	

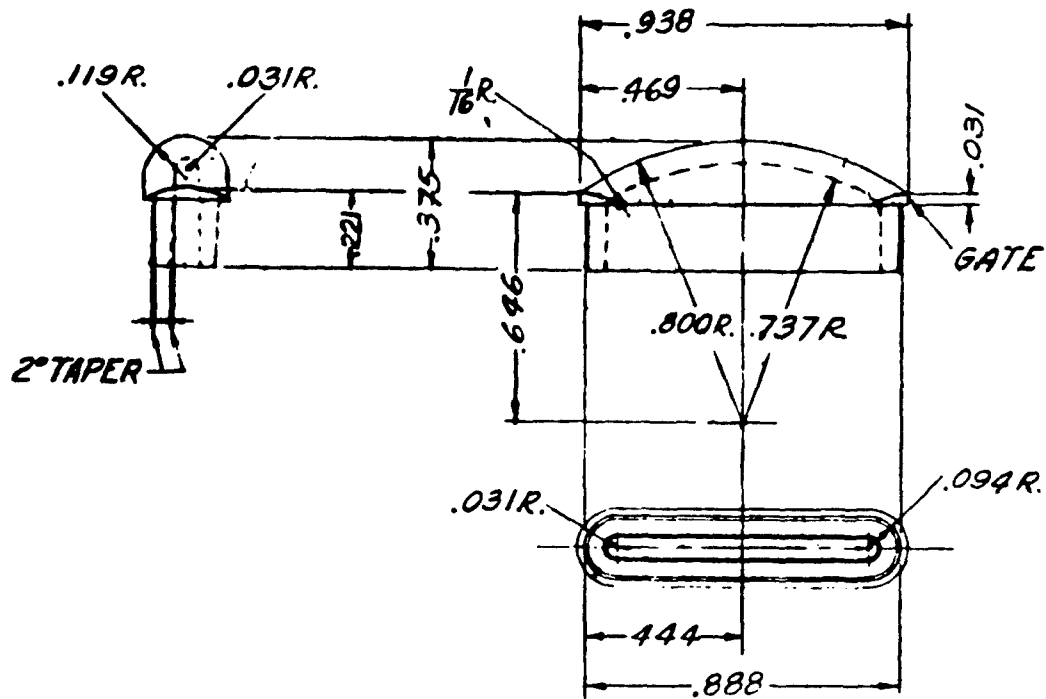
TITLE

SEALING DISC  
ASSEMBLY

SCALE  $\frac{1}{T}$

ALL FIELD NO. 100-450810, 100-450810

ESA-579367



NOTE:  
REMOVE ALL FINIS.

ETHYL CELLULOSE

1 REQ.

ISSUE 1 12-28-49  
ISSUE 2 1-8-49  
ISSUE 3 2-3-49

DR.	CH.
W. J. S.	ENG. G. F. S.
TR.	
APPL.	

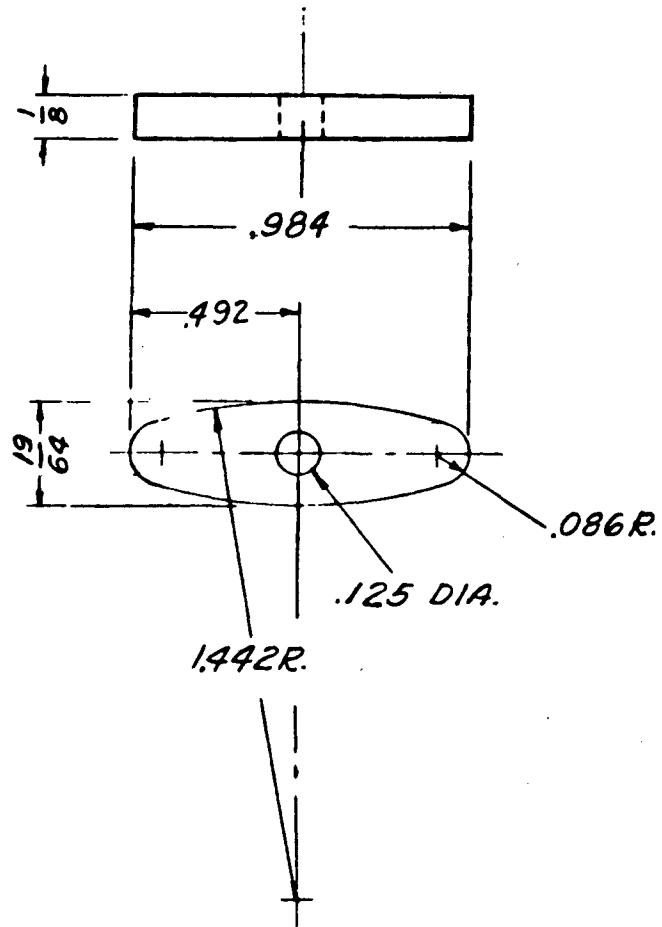
TITLE

IGNITER TUBE  
CAP

SCALE  $\frac{2}{1}$

BELL TELEPHONE LABORATORIES, INC., NEW YORK

ESA-585278



ETHYL CELLULOSE

1 REQ.

Issue 1 12-30-43

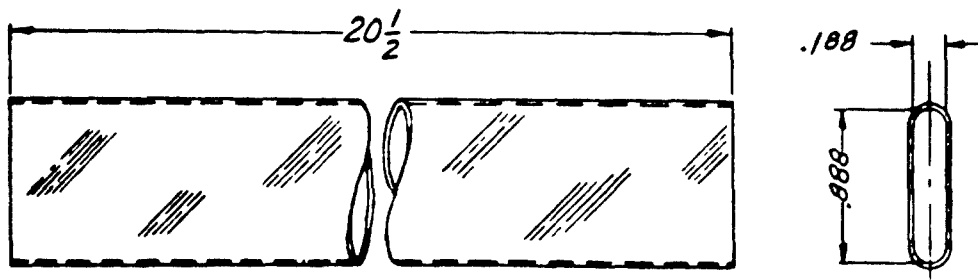
CH.	ENG.	G.F.S.
DR.	W.J.S.	TY.
APPL.		

TITLE

IGNITER TUBE  
PLUGSCALE  $\frac{2}{1}$ 

BELL TELEPHONE LABORATORIES, INC., NEW YORK

ESA-585279



ETHYL CELLULOSE

REQ.

ISSUE / 2-0-44

CH.  
W. J. S.

ENG. C. F. S.

TITLE

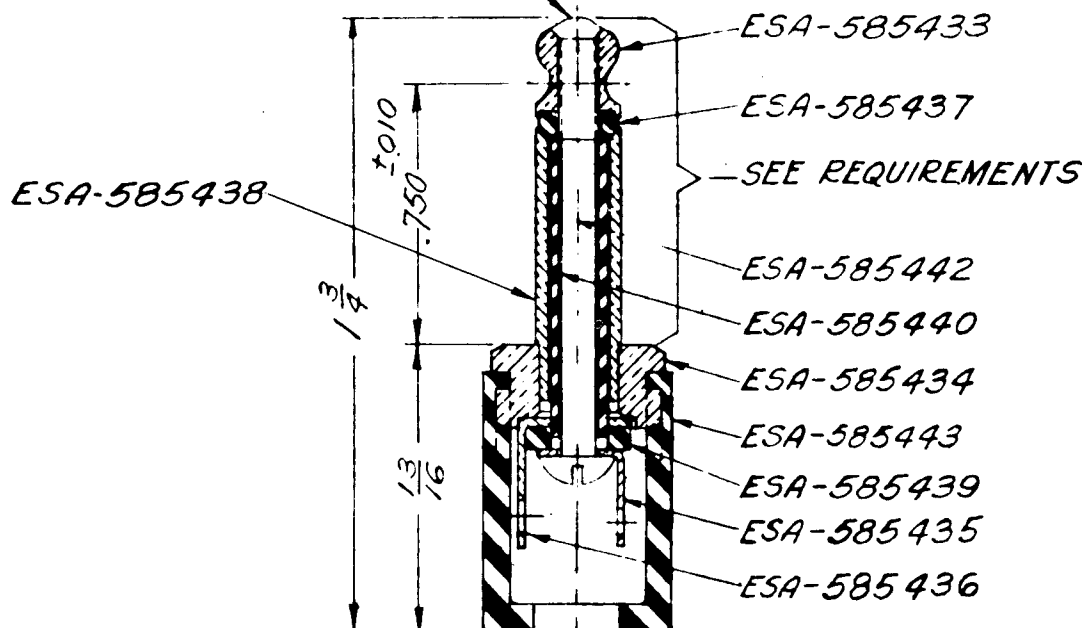
IGNITER TUBE

SCALE  $\frac{1}{4}$ 

BILL TELEPHONE LABORATORIES, INC., NEW YORK

ESA-585498

UPSET SCREW AFTER ASSEMBLING AND FORM SMOOTH TO CONTOUR OF TIP. TIP MUST BE TIGHT.



SECTION A-A

REQUIREMENTS:

THIS PORTION OF THE ASSEMBLY SHALL BE CAPABLE OF ENTERING A RIGID SLEEVE .252 IN. MAX. DIA. AND 9/8 LG. PLUG SHALL MOVE FREELY WHEN A PRESSURE OF 3 POUNDS IS APPLIED.

SAME AS #29 PLUG OF INSULINE CORP. OF AMERICA EXCEPT AS SHOWN.

1 REQ. 1A

Issue 1 1-27-44

CH.	ENG.	C.F.S.
DR.	W.J.S.	W.
APP.		

TITLE

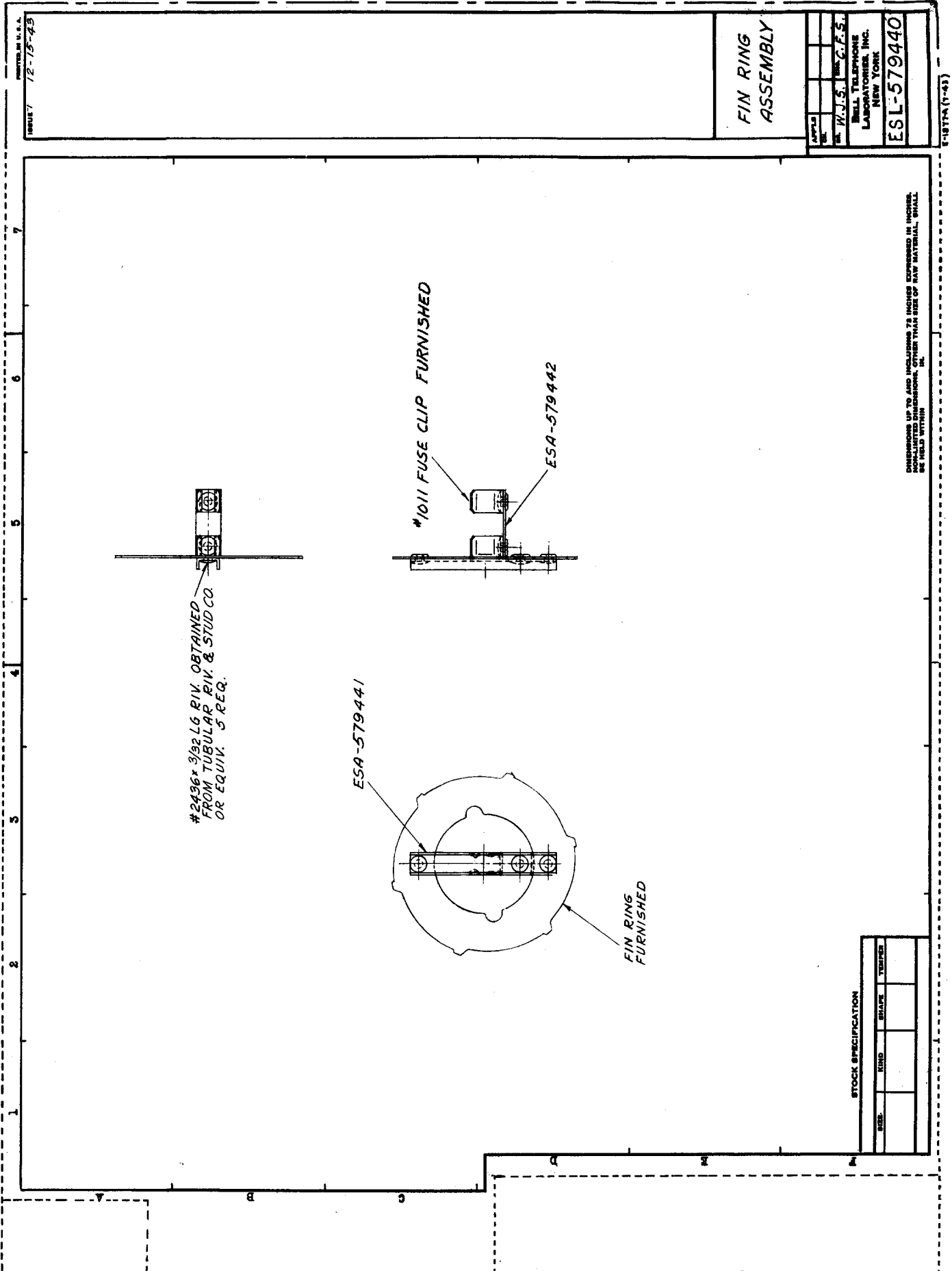
PLUG  
ASSEMBLY

SCALE  $\frac{2}{1}$

BELL TELEPHONE LABORATORIES, INC., NEW YORK

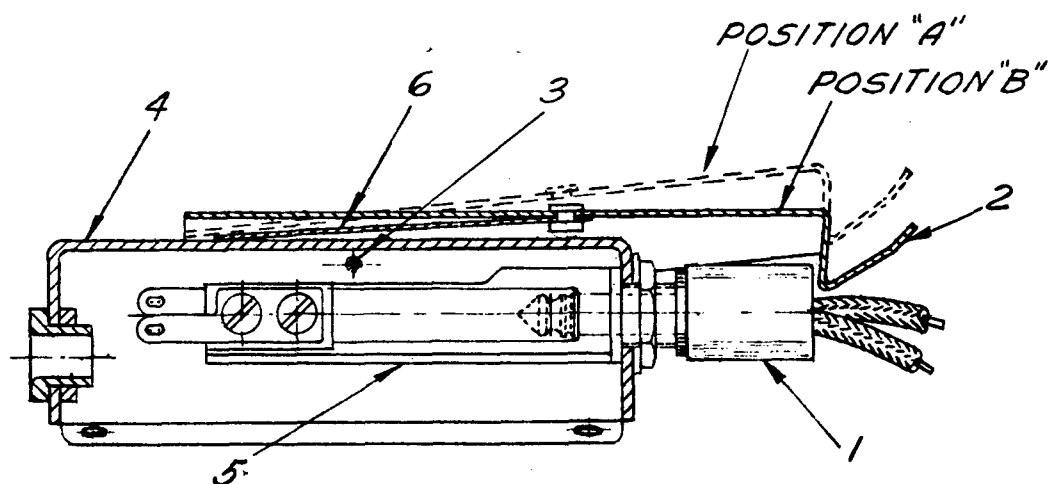
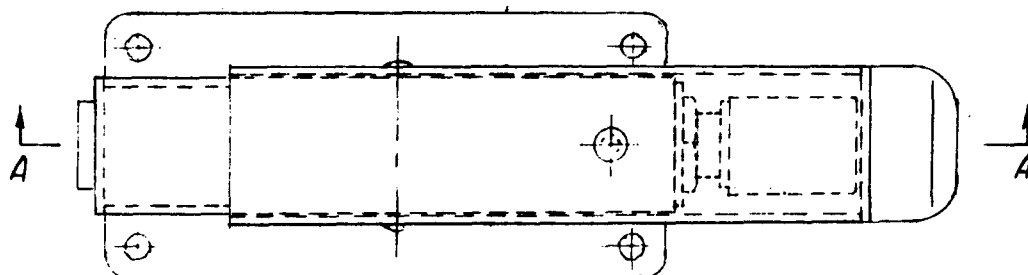
ESA-585441





# JACK MOUNTING

SCALE  $\frac{1}{4}$  APRIL 11, 1944  
ENG. C.F. SPAHN DR. W.J.S.



SECTION A-A

ESA-586126

PART VI  
HOLDING DEVICE

INTRODUCTION

At the request of the Sect. H., Div. 3, N.D.R.C., numerous devices for holding rockets in the launcher tube were developed by the Bell Telephone Laboratories, Inc.

The reason for the large number of designs was that changes in rocket construction involved changes in the method of engaging the rocket, new launchers imposed new space limitations and new uses introduced new forces which had to be resisted prior to firing.

DESCRIPTION OF MODELS

At the time the Bell Telephone Laboratories was requested to develop a rocket holding device, the only one available was of General Electric Co. design, shown on Page 138. As the development progressed changes in rocket and rocket launcher design and uses necessitated new designs. Also in some instances designs were proposed by different engineers to meet the same requirements. "Breadboard" or models for engineering study were made of all of the 18 designs covered in this report. Working samples were made of a large number and in several instances a number of samples were made for N.D.R.C. and Air Corps tests. Schematics and operating description of the 18 designs seriously considered are attached hereto.

Models 1, 2 and 3

The first request from the N.D.R.C. was for a holding and contacting device for a Revere type rocket equipped with contact rings on the fin flange. Models 1, Page 139, 2, Page 140, and 3, Page 141, were the proposals of different Engineers in response to this request. Models 1 and 2 were made up and submitted to Wright Field for test. Very limited information was given to the Bell Telephone Laboratories as to the results of these tests except that the proposal to employ contact rings on the rocket fin flange was abandoned. Model 1, Page 138, was used for the test and the holding device was apparently satisfactory. No information was obtainable as to whether Model 2, Page 139, was tested.

Models 4 and 7

Model 4, Page 142 is a redesign of Model 2 to provide a more compact construction. In Model 7, Page 145, a blast operated latch was added to Model 4 to prevent the holding device from releasing the rocket until after ignition.

Model 5

The N.D.R.C. requested a holding device which would engage some other point than the fin flange on the Revere type rocket. The fin flange offered considerable air resistance with resulting loss of range. Also a holding device was desired for the Budd type rocket which did not have a fin flange. Model #5,

Page 143, was developed in response to this request. It engaged an annular ring in the rocket. A sample was made up and tested by the N.D.R.C. by firing 79 rockets. The results were reported satisfactory. Two more samples were made and the N.D.R.C. tested them with 80 rockets. Again the results were satisfactory.

A sample was furnished to Col. Donicht of the Air Corps for test on a launcher that they were developing. As a result of this test, the loading chambers of eight launchers were equipped with this holding device for the Air Corps. No report was received as to the results of the test of this lot.

At the request of the N.D.R.C. a set of drawings and a sample of this design was furnished to the Budd Wheel Co. They made up six of the holding devices incorporating a number of their own ideas. This lot was never tested.

#### Models 6, 8 and 9

These were alternate designs given consideration at the same time as Model 5, Page 143. Models 6, Page 144, and 9, Page 147, engaged an annular ring in the rocket and Model 8, Page 146, engaged the tapered ends of the rocket.

#### Models 10, 11, 12, 13 and 14

The designs of Model 10 to 14 shown on Pages 148 to 152, were investigated more or less intensively with a view to obtaining a simpler and more compact construction. Laboratory studies and tests indicated that Model 11, Page 149, gave the most promise of being comparable in performance with Model 5, Page 143. A sample was therefore made and given firing tests. Its performance

was satisfactory. As confirmation, a second sample was made and tested with satisfactory results. Six more were made and mounted on two cluster type launchers. In firing tests from a plane it was found that the force of the back blast from the first rocket forced the rockets in the other two tubes of the cluster back out of the holding device. Further study of this condition by the Air Corps showed that the rearward release of the holding device should have been 1000 pounds rather than the 600 pounds previously specified. As this was a feature which could be easily corrected, and as it was desirable to complete the test, only one tube in each cluster was employed for the rest of the firings. Under these conditions the holding devices performed satisfactorily.

An assembly drawing ES-586161, Page 158, and photograph 121810, Page 160 of the Model 11, Page 161, holding device, is included in this report.

#### Models 15, 16 and 17

Improvements in rocket design, subsequent to the original request, practically eliminated the rocket partings so that a rearward release was no longer deemed necessary for the holding device. To take advantage of this and to further simplify the holding device, Models 15, Page 153, 16, Page 154 and 17, Page 155 were developed. Of these, Model 15, Page 153, was made up for firing tests. As a result of the satisfactory performance in this test, the N.D.R.C. requested 25 additional samples. Before

these could be completed, it was decided to eliminate the annular groove in the rocket which the holding device employed for engagement. Later the spinning rocket was developed and this rocket had an annular groove. Therefore, for the redesigned 6 tube automatic launcher, it was decided to employ this holding device.

The assembly drawing ESO-586005, Page 159 and photograph 121811, Page 161, of the Model 15, Page 153 holding device, is included in this report.

#### Model 18

This design was a simple construction employing the forward force to shear a metal tip on the ignition plug rather than springs to control the release value. Firing tests indicated it to be satisfactory. This holding device, Model 18, Page 156, is further shown in drawings ESO-586023, Page and ESO-586074, Page

#### ENGINEERING CONSIDERATIONS

What are believed to be the salient engineering considerations for a rocket holding device are outlined below. As was discussed under "Description of Models" some of these points were revised during the course of the development due to changes in requirements. Table I, Page 162 shows how each of the models can be rated with respect to the different features.

#### Point of Rocket Engagement

Various points in the outer contour of the rockets are employed as a means for engaging the holding devices.

### Loading

All of the holding devices except Model #6, Page 144 , may be loaded from either the front or rear end of the launching tube.

### Release

Most of the holding devices will release both forward and, in case of a parting, rearward but in case of holding devices engaging in the groove, it is possible that no rearward release is necessary as such release is only provided to take care of a parting of the rocket. The rocket moves forward a short distance before the parting takes place and this will release the holding device. When the parting takes place, the rear half of the rocket will come backward before the latching lever has had time to move down into a position to engage the rocket.

### "Dig In" Characteristic

Some models have a "Dig In" feature which utilizes the difference in the slope of the rocket nose and the sidewalls of the groove. The figures in the "Force Diagram", Page 157 , serve to illustrate how this difference is taken advantage of. In figures 1, Page 157 and 2, Page 157 , the wedges have the gentle slope of the rocket nose and in both cases the pressure normal to the slope tends to rotate the lever in a direction which will raise it. In figures 3, Page 157 and 4, Page 157 the wedges have the steep slope of the sidewalls of the groove and in figure 4, Page 157 the pressure normal to the slope also tends to rotate the lever in a direction which will raise it but in figure 3, Page 157 ,



this normal pressure will cause the lever to rotate in a direction which will cause it to go down or "dig in."

#### Cushioning

Some models have a cushioning feature which permits the latching lever to move parallel to the motion of the rocket for a short distance before the holding device releases. This is a desirable feature as in case of a rigid stop the force required to stop a rocket being loaded, or to hold a loaded rocket when the launcher is suddenly accelerated or decelerated, may far exceed the force which is specified as a release value for the holding device.

#### "Overshooting" in Loading

When rockets are loaded in launching tubes equipped with some of the models "overshooting" or pushing the rocket past the holding devices is comparatively easy. In the majority of cases this does not occur when the holding device has a "Dig In" characteristic or is either cushioned or does not release for motion of the rocket in the direction in which it is being loaded.

#### Effect on Release of Angle of Engagement Surface on Rocket

With some models this angle is critical in that the holding device will release at lower values as this surface varies by increasing angles from a perpendicular to the major axis of the rocket. For other models the release value is relatively unchanged for an angle that varies from a perpendicular to approximately 30 degrees.

Quick Release

The latching lever of some of the holding devices start sliding up the engagement surface on the rocket as soon as the rocket starts moving forward or rearward from the latched position. With other holding devices the rocket can move for a fraction of an inch without the latching lever raising at all and then if the rocket force exceeds the release value they raise quickly. This latter type are referred to as "Quick Release" holding devices.

FIRING TESTS

The following table is a record of the firing tests made with the various models.

<u>Approx. Date</u>	<u>Model No.</u>	<u>No. Tested</u>	<u>No. of Rockets Fired</u>	<u>Results of Tests</u>
10/7/43	1	1	No information	Satisfactory
10/21/43	5	1	79	Satisfactory
11/12/43	5	2	80	Satisfactory
11/27/43	5	1	No information	(Satisfactory - Del. to Col. Donicht)
12/15/43	11	1	No information	Satisfactory
1/30/44	11	1	15	Satisfactory
2/3/44	5	8	No information	(No information - Del. to Col. Donicht)
2/20/44 to 3/15/44	11	6	50	*Satisfactory except for releasing on blast from adjacent tube.
4/5/44	15	1	5	Satisfactory
4/5/44	18	1	5	Satisfactory

-----

\*The releasing of the holding device on the blast from a rocket fired from an adjacent tube was due to too low a release value. An increased tension of the spring in the holding device should take care of this.

PART VI  
LIST OF ILLUSTRATIONS

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Table I - Rating of Various Models with Respect to their Features	162

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October 21, 1943, letter from R. F. Mallina to H. O. Siegmund on Holding and Contacting Devices.

November 4, 1943, Memo for File by Lucy Birzis on Holding and Contacting Devices.

November 12, 1943, Memo for File by C. A. Hasslacher on Holding and Contacting Devices.

December 2, 1943, Memo for File by C. F. Spahn on Contacting Devices.

January 1, 1944, Memo for File by F. A. Zupa on Holding and Contacting Devices.

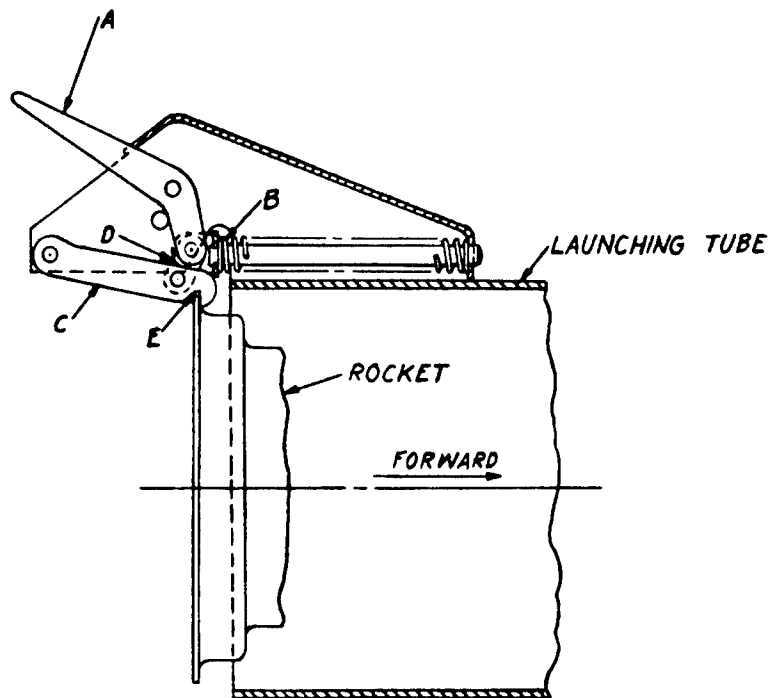
April 11, 1944, Memo for File by C. F. Spahn on a Holding and Contacting Devices.

April 27, 1944, Memo for File by C. F. Spahn on Holding and Contacting Devices.

May 8, 1944, Memo for File by C. F. Spahn on Various Fin Designs for the 4-1/2" Rocket.

May 12, 1944, Memo for File by J. M. Melick on Rocket Holding Devices.

August 12, 1944, Memo for File by C. F. Spahn on Holding and Contacting Devices.



#### G.E. Model

##### Loading from Front End

Release lever A is manually depressed. This compresses the spring B and raises the toggle members C and D. The rocket is pushed on back beyond the latch. Release lever A is then released allowing the other members to return to normal. The rocket is pushed forward camming up the member C until the slot E snaps over the flange on the rocket.

##### Loading from Rear End

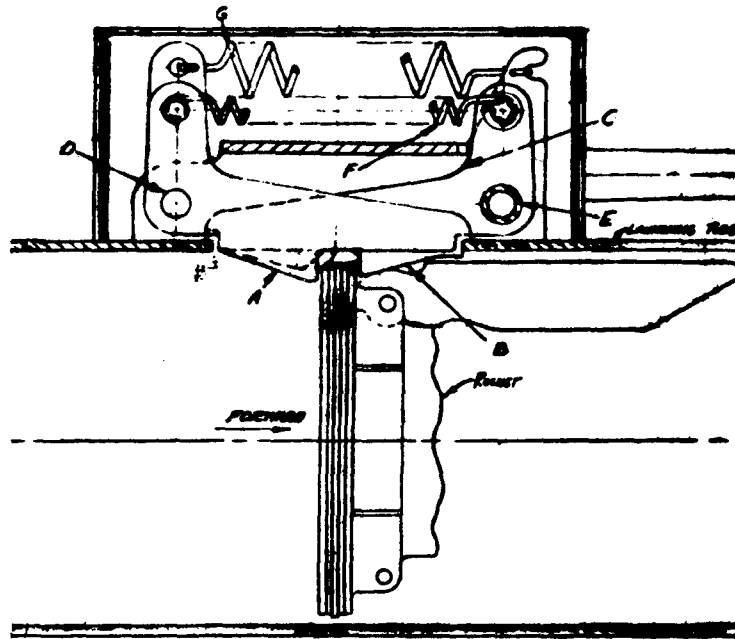
The rocket is pushed forward camming up the member C until the slot E snaps over the flange on the rocket.

##### Firing - Rocket Moving Forward

A slight slope of the slot E causes the member C to rise and the toggle action between the members C and D compresses the spring B.

##### Firing - Rocket Moving Rearward

Not designed to release with the rocket moving in this direction.

MODEL #1Loading from Front End

Lever B rotates about pin D elongating spring G.

Loading from Rear End

Lever A rotates about pin D elongating spring F.

Firing - Rocket Moving Forward

Lever B rotates about pin D elongating spring G.

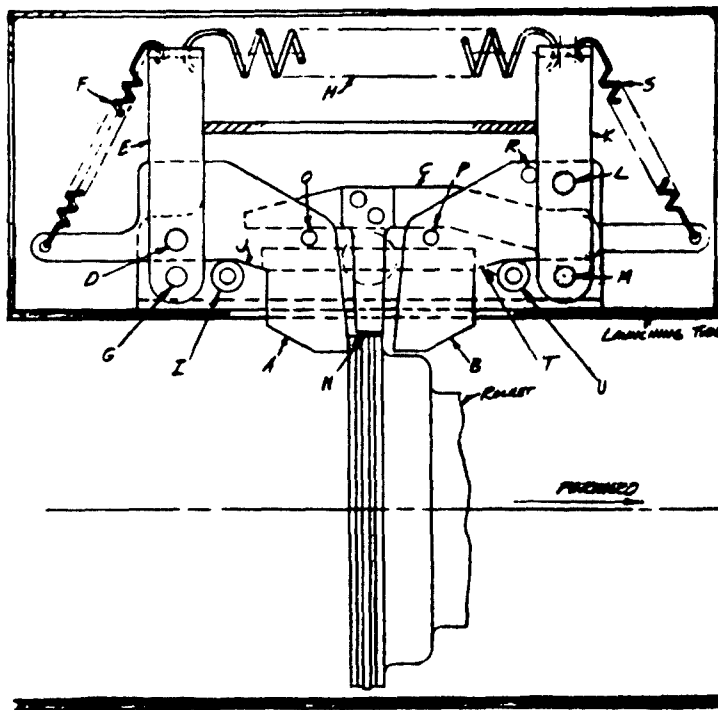
Firing - Rocket Moving Rearward

Lever A tends to rotate downward holding rocket.

Ignition

Due to cam surfaces insulated lever C rotates on pin E against spring F and in normal position makes contact with center slip ring on rocket and levers A and B make contact with outer rings. To insure good electrical connections levers A and C are equipped with knife edges at the points they make contact with the slip rings.

Suggested by: C. F. SPAHN

**MODEL #2****Loading from Front End**

Lever B rotates about pin L and lever K about pin M elongating spring H. Pin R causes lever K to rotate.

**Loading from Rear End**

Lever A rotates about pin D elongating spring F.

**Firing - Rocket Moving Forward**

Lever B moves horizontally applying pressure to lever K by means of pin L and lever K rotates about pin M elongating spring H. Cam surface T on lever B when it reaches roller U, rotates lever B about pin L.

**Firing - Rocket Moving Rearward**

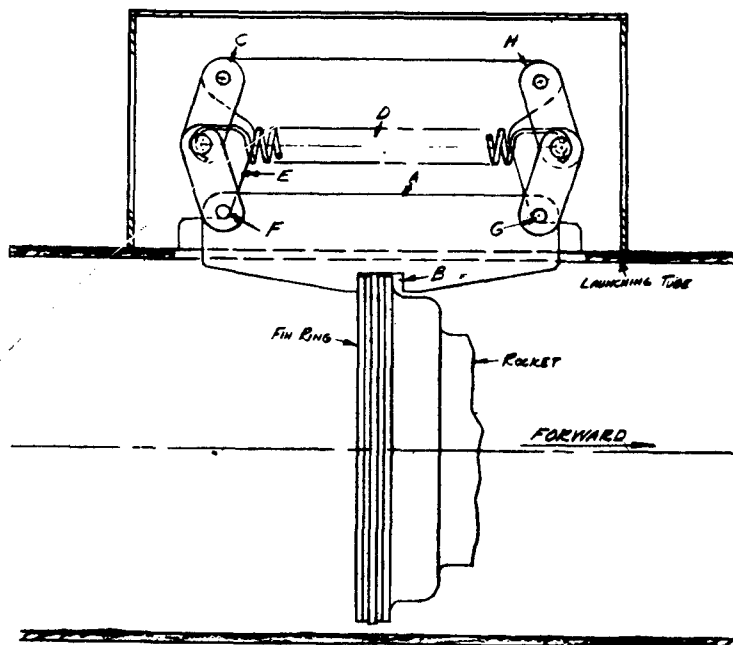
Lever A moves horizontally applying pressure to lever E by means of pin D and lever E rotates about pin G elongating spring F. Cam surface J on lever A when it reaches roller I, rotates lever A about pin D.

**Ignition**

Due to pins O and P lever C is rotated about pin M against spring S and in normal position insulated detail N on lever C makes contact with center slipring on rocket and levers A and B make contact with outer rings.

**Notes:** As levers E and K are of equal length, the forces required to rotate the two levers is inversely proportional to the distance between the pins D and G and the pins L and M. This permits different releasing values forward and rearward.

**Suggested by:** J. M. MELICK

**MODEL #3****Loading from Front End**

Detail A which is provided with a slot B which fits over the fin flange and sliprings will pivot about the pin F collapsing the toggle H and elongating the spring D. The stationary cam E will guide the pins F and G when moved.

**Loading from Rear End**

Detail A will pivot about the pin G collapsing the toggle C and elongating the spring D.

**Firing - Rocket Moving Forward**

Detail A tends to move horizontally but the rear end is cammed upward by the pin F rubbing against the stationary cam E, collapsing the toggle C and elongating the spring D.

**Firing - Rocket Moving Rearward**

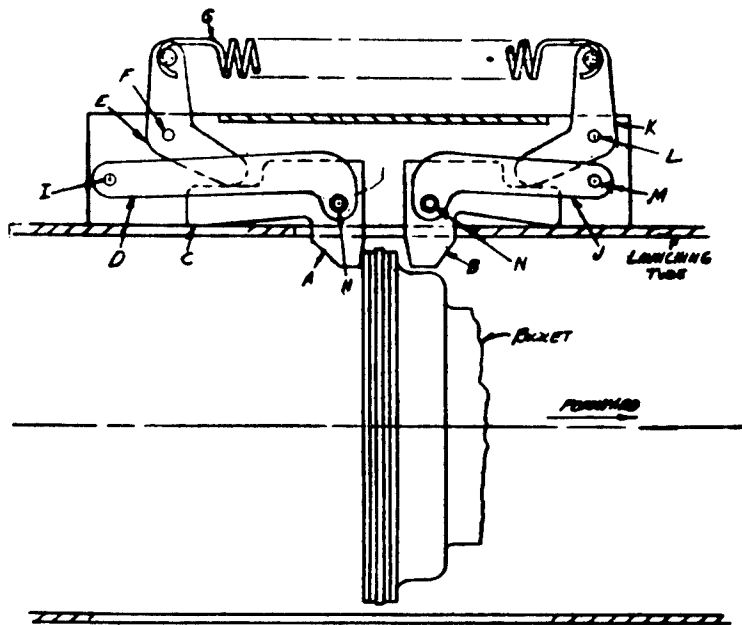
Detail A tends to move horizontally but the front end is cammed upward by the pin G rubbing against the stationary cam E, collapsing the toggle H and elongating the spring D.

**Ignition**

Contact to the center slipring would be provided by an insulated lever which is not shown and detail A would make contact with the outer sliprings.

**Suggested by:** C. A. HASSLACHER





#### MODEL #4

##### Loading from Front End

Lever B rises causing lever K to rotate about pin L elongating spring G and also lever J rotates on pin M due to pin N.

##### Loading from Rear End

Lever A rises causing lever E to rotate on pin F elongating spring G and also lever D rotates on pin I due to pin H.

##### Firing - Rocket Moving Forward

Lever B rotates on pin N which in turn rotates lever K on pin L elongating spring G. When the normal to the contacting surface between lever B and the rocket falls above the pin M, the lever J rotates upward on pin M permitting lever B to rise.

##### Firing - Rocket Moving Rearward

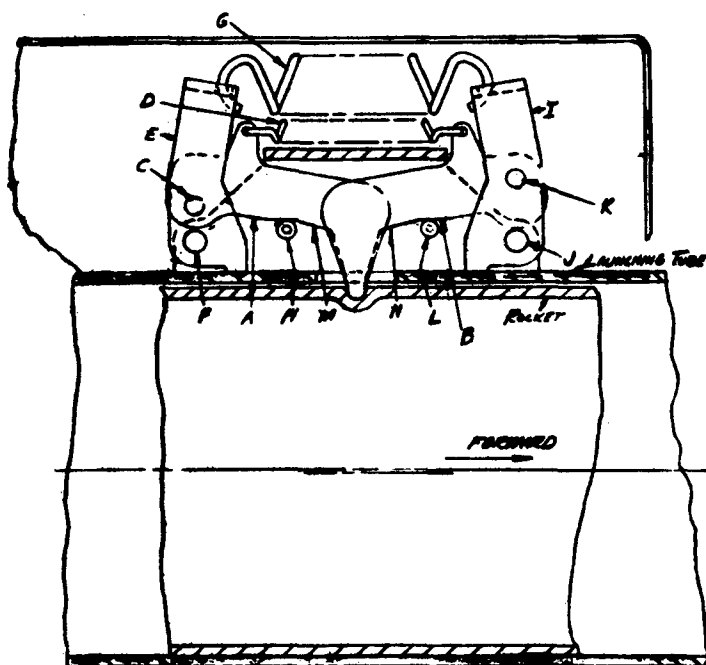
Lever A rotates on pin H which in turn rotates lever E on pin F elongating spring G. When the normal to the contacting surface between lever A and the rocket falls above the pin I, the lever D rotates upward on pin I permitting lever A to rise.

##### Ignition

Contact to the center slipring would be provided by an insulated lever which is not shown, and levers A and B would make contact with the outer sliprings.

Notes: The relative release values forward and rearward will be inversely proportional to the distance between the pin N and the point of contact point of levers B and K and the distance between the pin H and the point of contact of levers A and E.

Suggested by: J. M. MELICK

**MODEL #5****Loading from Front End**

Levers A and B rotate on pins C and K elongating spring D.

**Loading from Rear End**

Same as loading from Front End.

**Firing - Rocket Moving Forward**

Lever B moves horizontally applying pressure to lever I by means of pin K and lever I rotates on pin J elongating spring G. Cam surface N on lever B when it reaches roller L, rotates lever B about pin K.

**Firing - Rocket Moving Rearward**

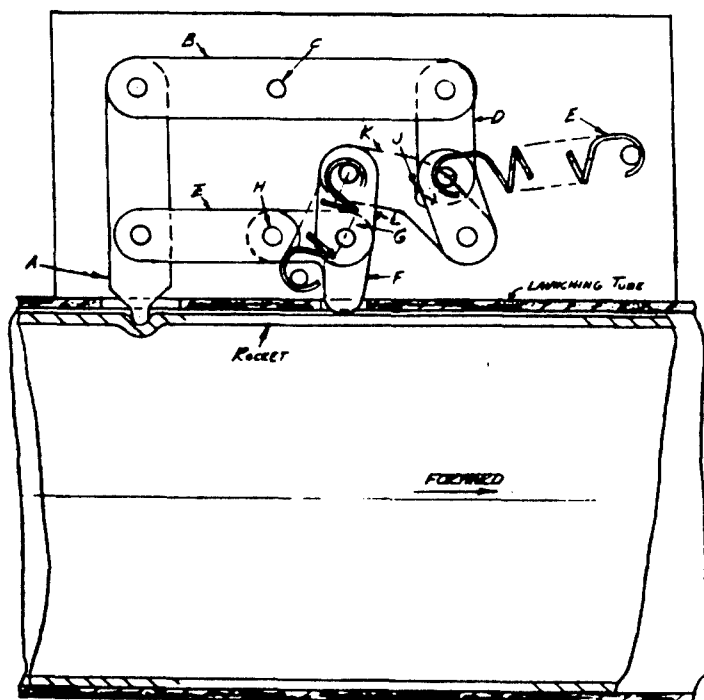
Lever A moves horizontally applying pressure to lever E by means of pin C and lever E rotates on pin F elongating spring G. Cam surface M on lever A when it reaches roller H, rotates lever A about pin C.

**Ignition**

A jack will be provided for the plug on the rocket.

**Notes:** As levers E and I are of equal length, the forces required to rotate the two levers is inversely proportional to the distances between the pins C and F and the pins J and K. This permits different release values forward and rearward.

**Suggested by:** J. M. MELICK

MODEL #6Loading Front End

Not designed to load from front end.

Loading Rear End

As the tapered nose of the rocket passes under lever A it raises link A which rotates levers B and I about pins C and H respectively. As the rocket nose passes under lever F, lever F rotates upward about pin H and rotates lever K about pin J by means of link L and spring G is elongated. Rotation of lever L tends to partially straighten out toggle O. When lever A drops into the rocket groove, toggle D will straighten out so that only a small force from spring E will offer tremendous resistance to raising lever A.

Firing - Rocket Moving Forward

Lever A is raised by the camming action of the sidewall of the rocket groove and levers B and I are rotated about pins C and H respectively. Rotation of lever B will collapse toggle D due to the other end of toggle D being held rigidly due to lever F being held out of the tube by the rocket.

Firing - Rocket Moving Rearward

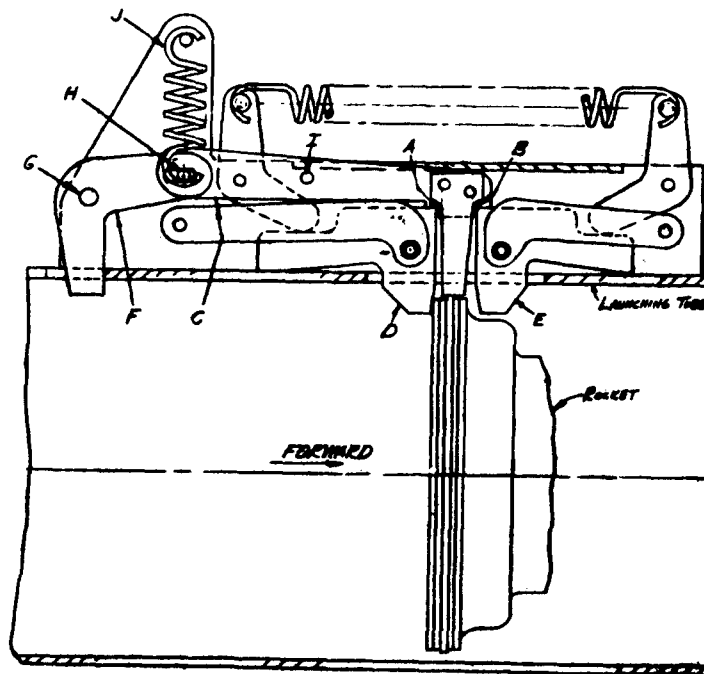
Same as for "Firing - Rocket Moving Forward".

Ignition

A jack will be provided for the plug on the rocket.

Notes: Due to the toggle D being practically straight at firing and partially collapsed at loading, the force on A due to spring E is high for firing and low for loading.

Suggested by: C. A. HASSLACHER

MODEL #7Loading from Front End

Same as for Model #4

Loading from Rear End

Same as for Model #4

Firing - Rocket Moving Forward

Same as for Model #4 except as covered below under "Notes".

Firing - Rocket Moving Rearward

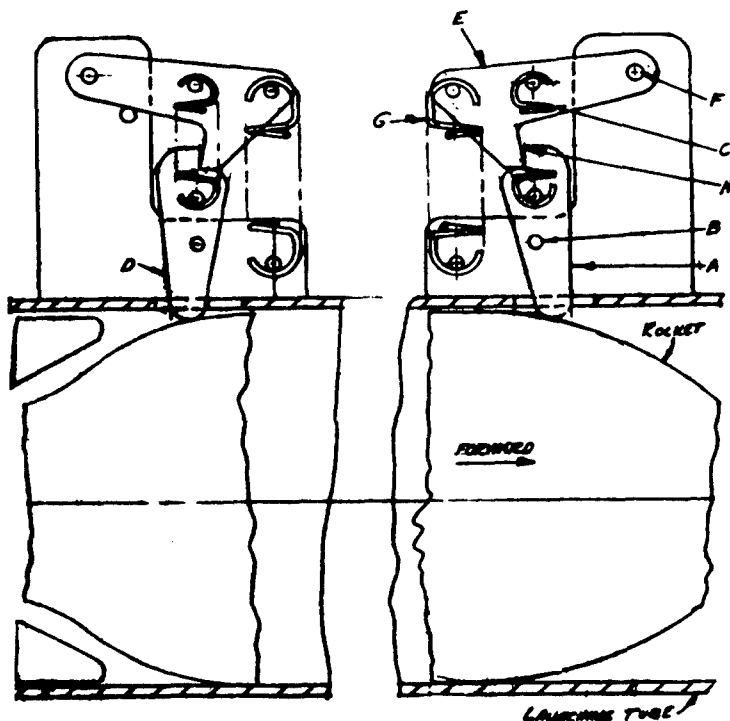
Same as for Model #4 except as covered below under "Notes".

Ignition

Same as for Model #4.

Notes: The shoulders A and B on the lever C prevent the rotation of levers D and E so that the rocket is held until the blast causes the lever F to rotate about the pin G. This in turn by means of the pin H causes the lever C to turn about the pin I so as to release the levers D and E. The spring J pulls the locking linkage back into place after firing.

Locking Linkage Suggested by: R. F. MALLINA

**MODEL #8****Loading from Front End**

Lever A will rotate about pin B elongating spring C. Rearward motion of the rocket will be stopped by lever D at which time lever A will rotate back into the position shown engaging the front end of the rocket.

**Loading from Rear End**

Rear holding device will operate the same as front holding device under "Loading from Front End".

**Firing - Rocket Moving Forward**

Lever A will rotate about pin B and cam surface H on lever A will cause lever E to rotate about pin F elongating spring G.

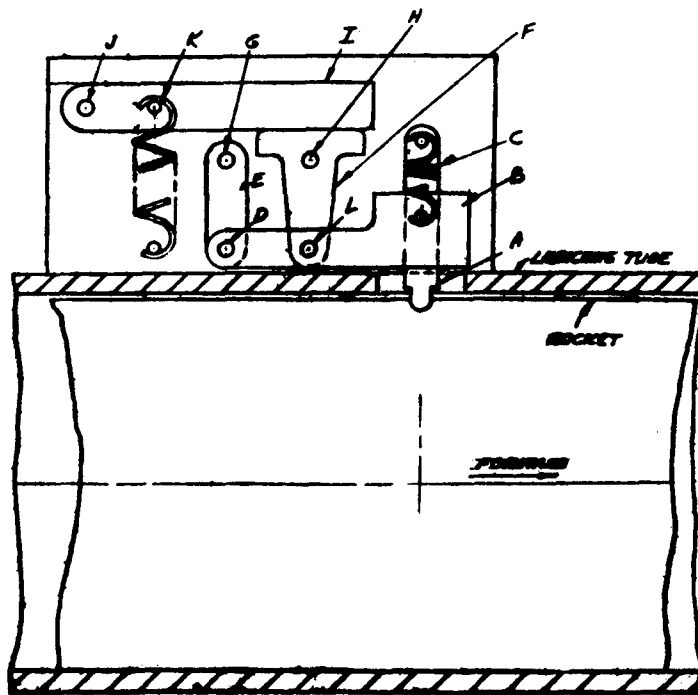
**Firing - Rocket Moving Rearward**

Rear holding device will operate the same as front holding device under "Firing - Rocket Moving Forward".

**Ignition**

A jack will be provided for the plug in the rocket.

**Suggested by:** C. A. HASSLACHER

**MODEL #9****Loading from Front End**

Detail A is raised vertically in a groove in lever B elongating spring C.

**Loading from Rear End**

Same as "Loading from Front End".

**Firing - Rocket Moving Forward**

Lever B moves horizontally causing levers E and F to rotate on pins G and H due to pins D and L. Rotation of lever F causes rotation of lever I on pin J elongating spring K.

**Firing - Rocket Moving Rearward**

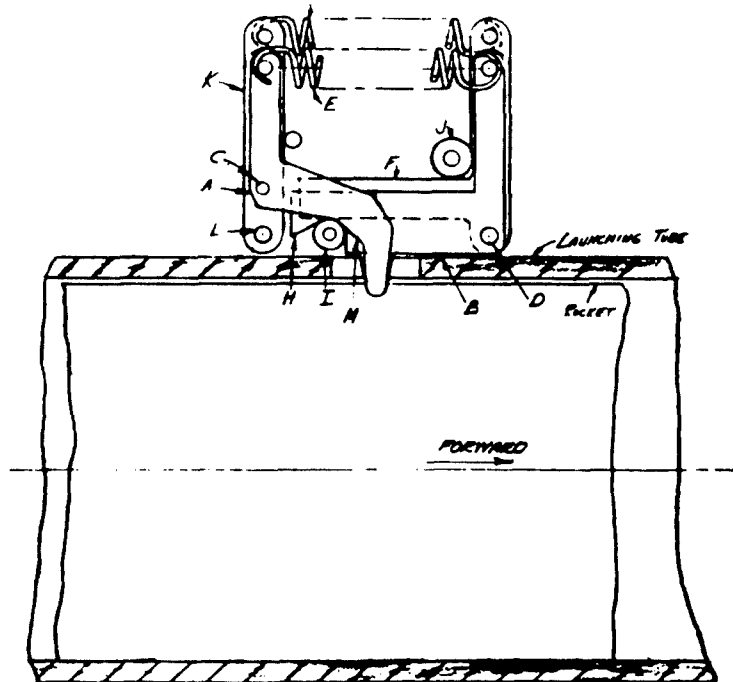
Same as "Firing - Rocket Moving Forward".

**Ignition**

A jack will be provided for the plug on the rocket.

Notes: Due to the difference in the points of contact between links F and I when F is rotated in the two directions, different release values will be obtained for forward and rearward release.

Suggested by: C. A. HASSLACHER.

MODEL #10Loading from Front

Levers A and B rotate about pins C and D respectively elongating spring E.

Loading from Rear

Same as "Loading from Front".

Firing - Rocket Moving Forward

Lever B moves forward horizontally and due to pin D lever F will move with it elongating spring G. When the slope H on lever B reaches the roller I it will rotate lever B about pin D. Lever A will rotate about pin C.

Firing - Rocket Moving Rearward

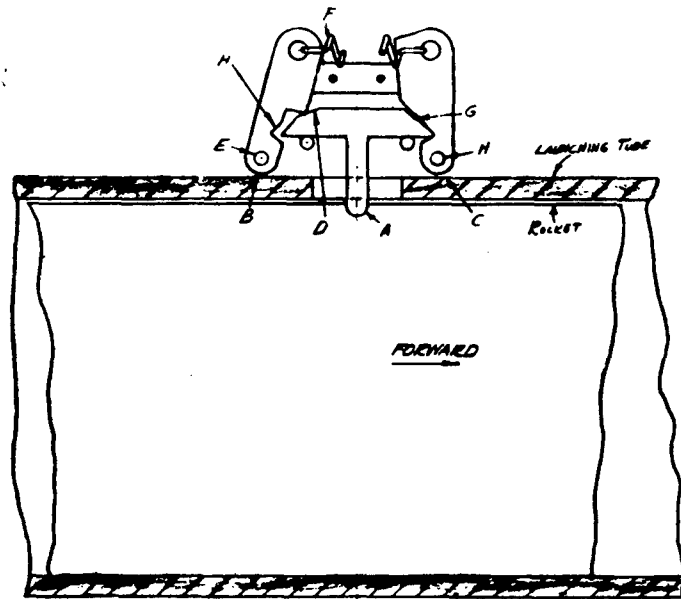
Lever A moves rearward horizontally and due to pin C lever K will rotate about pin L elongating spring G. When the slope M on lever A reaches the roller I, it will rotate lever A about pin C. Lever B will rotate about pin D.

Ignition

A jack will be provided for the plug on the rocket.

Notes: As lever F moves horizontally and the lever K rotates, spring G will be elongated more for rearward than for forward release.

Suggested by: J. M. MELICK



#### MODEL #11

##### Loading from Front End

Lever A pivots about the end engaged in the notch in lever C and due to the slope D on lever A, lever B is rotated about pin E elongating spring F.

##### Loading from Rear End

Same as "Loading from Front End".

##### Firing - Rocket Moving Forward

Lever A moves horizontally rotating lever C about pin H and elongating spring F until the angle between surface G of the notch in lever C forms an angle of  $90^\circ$  plus the angle of friction with a line drawn from where the rocket presses against lever A to the point where the lever A presses against the surface G. When lever C has rotated this distance, lever A will slip out of the notch in lever C and the front end of lever A will rise.

##### Firing - Rocket Moving Rearward

Lever A moves horizontally engaging the notch in lever B, rotating lever B and elongating spring F until the angle between surface H of the notch in lever B forms an angle of  $90^\circ$  plus the angle of friction with a line drawn from where the rocket presses against lever A to where the lever A presses against the surface H. When lever B has rotated this distance lever A will slip out of the notch in lever B and the rear end of lever B will rise.

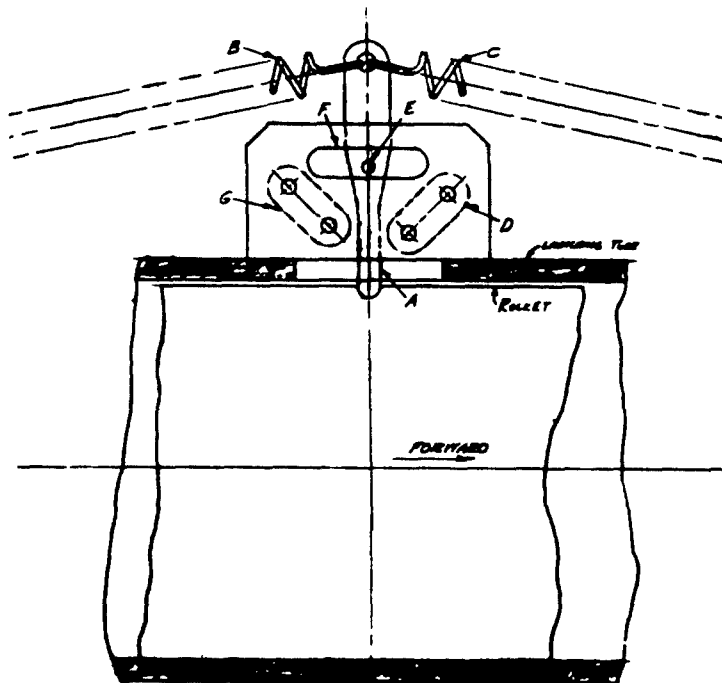
##### Ignition

A jack will be provided for the plug on the rocket.

Notes: Difference in the relative forward and rearward release values may be obtained by varying the angles of the surfaces G and H respectively.

Suggested by: J. M. MELICK



MODEL #12Loading from Front End

Lever A raises, elongating springs B and C.

Loading from Rear End

Same as "Loading from Front End".

Firing - Rocket Moving Forward

Lever A pivots around lug D elongating spring C. Pin E as it moves along the lower surface of slot F raises A out of the groove.

Firing - Rocket Moving Rearward

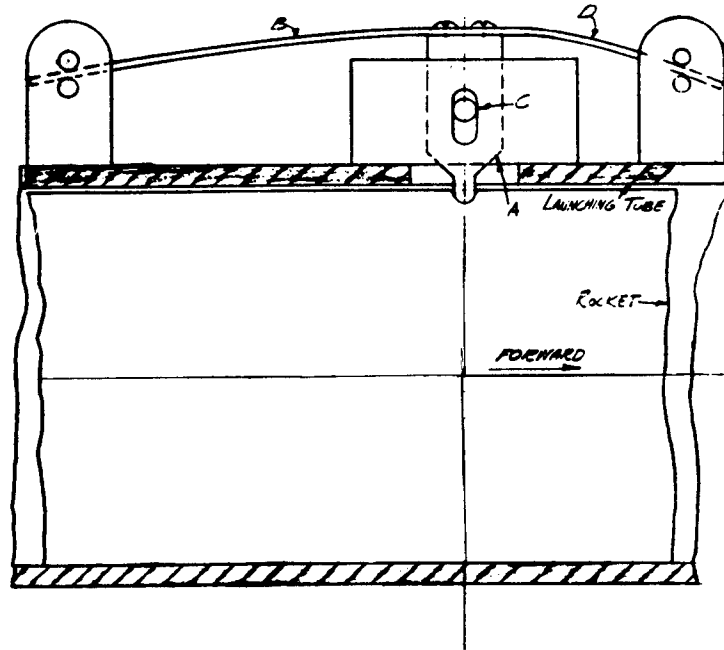
Same as "Firing - Rocket Moving Forward".

Ignition

A jack will be provided for the plug on the rocket.

Notes: The location of the lugs D and G vary the lever ratios in the lever A so that different forward and rearward release values may be obtained.

Suggested by: DR. C. N. HICKMAN

MODEL #13Loading from Front End

Lever A raises, deflecting springs B and D.

Loading from Rear End

Same as "Loading from Front End"

Firing - Rocket Moving Forward

Lever A pivots about pin C bending springs B and D until it cams out of the groove.

Firing - Rocket Moving Forward

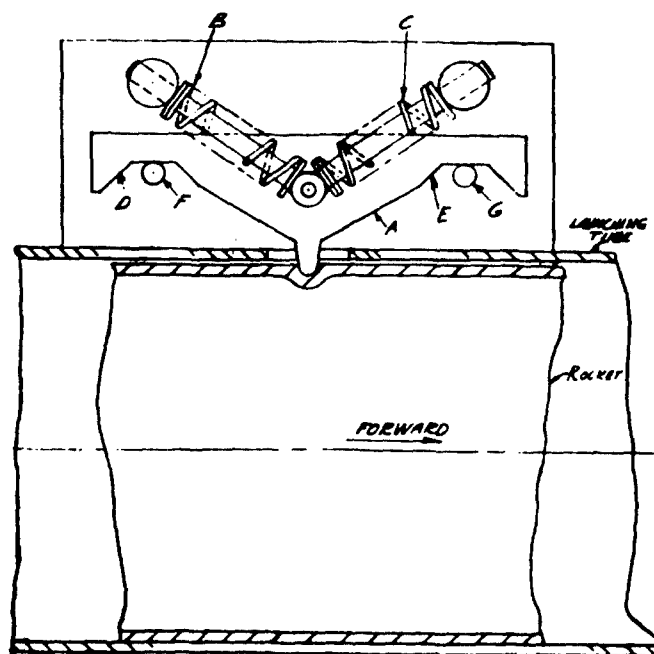
Same as "Firing - Rocket Moving Forward".

Ignition

A jack will be provided for the plug on the rocket.

Notes: Due to spring D being short there will be a high percentage difference in its effective length for releasing forward and rearward. Due to spring B being long the percentage change in effective length is small and therefore does not offset the changes in the effective length of spring D. This permits control of the relative forward and rearward release values.

Suggested by: DR. C. N. HICKMAN

MODEL #14Loading from Front End

Detail A raises compressing springs B and C.

Loading from Rear End

Same as "Loading from Front End".

Firing - Rocket Moving Forward

Detail A tends to move forward until slopes D and E on detail A come against pins F and G respectively. At this point surface E will raise the front end of detail A. Also, surface D will raise the rear end of detail A and also tend to cause detail A to rotate about pin F.

Firing - Rocket Moving Rearward

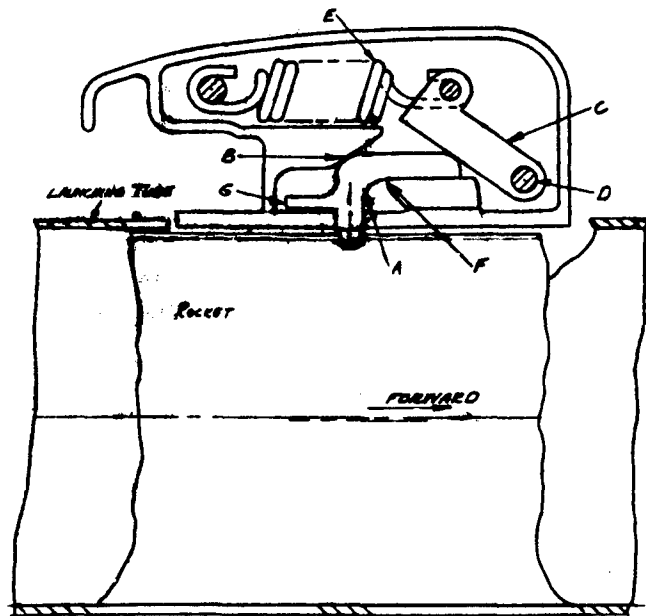
Same as "Firing - Rocket Moving Forward"

Ignition

A jack will be provided for the plug on the rocket.

Notes: This latch was designed with a view of providing a braking action during loading by means of radial pressure on the rocket.

Suggested by: C. A. HASSLACHER

MODEL #15Loading from Front End

Detail A rises with slope B forcing it forward rotating lever C about pin D and elongating spring E.

Loading from Rear End

Same as "Loading from Front End"

Firing - Rocket Moving Forward

Detail A moves forward horizontally rotating lever C about pin D and elongating spring E. When the vertical surface of detail A strikes against the point F, detail A will tend to rotate about point F but lug G will tend to prevent this except as the vertical surface of detail A moves upward over point F. When detail A rotates, the surface of lever C is approximately tangent to the arc over which the forward end of detail A moves so that the resistance to this rotation is largely frictional.

Firing - Rocket Moving Rearward

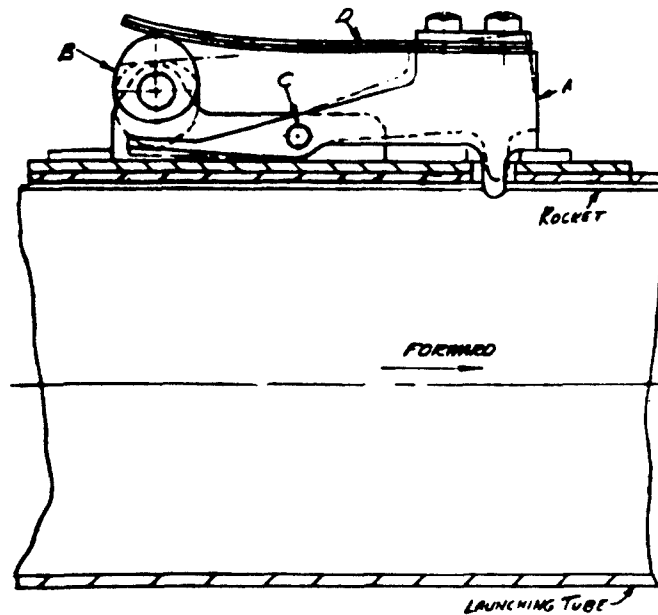
Detail A will tend to move rearward horizontally but slope B will tend to make it dig in tighter.

Igniter

A jack will be provided for the plug on the socket.

Notes: Lug G on detail A is required to return detail A to normal after firing.

Suggested by: J. M. MELICK

**MODEL #16****Loading from Front End**

Before loading cam B is rotated to an intermediate point in which position a slight tension is applied in spring D and the rear end of lever A will be free to rotate. The rocket will rotate lever A about pin C against the tension in spring D.

**Loading from Rear End**

Same as "Loading from Front End."

**Firing - Rocket Moving Forward**

Before firing cam B is rotated to the position in which the maximum tension is applied in spring D and the rear end of lever A will be free to rotate. The rocket will cam lever A out of the groove by rotating it about pin C against the tension in spring D.

**Firing - Rocket Moving Rearward**

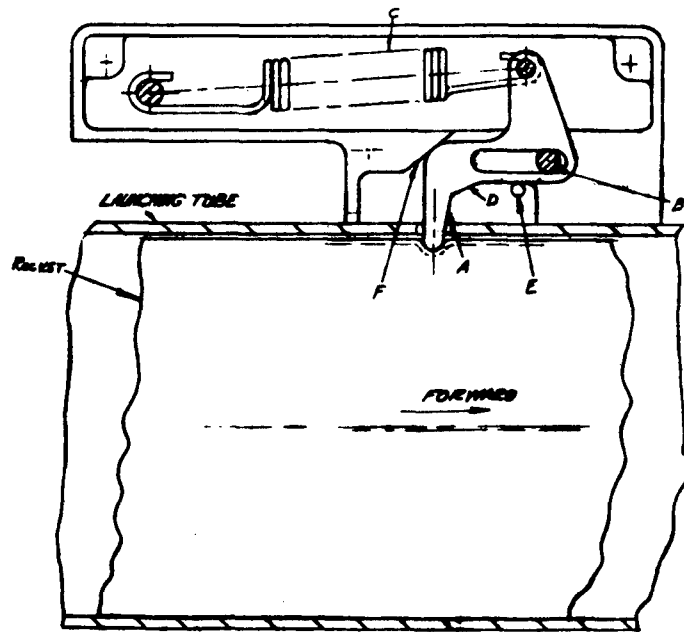
If the sidewall of the groove is moderately steep lever A will dig in and if not so steep detail A will be cammed out of the groove as "Firing - Rocket Moving Forward".

**Ignition**

A jack will be provided for the plug on the rocket.

**Notes:** For unloading cam B is rotated to the point where it applies no pressure to the spring D and rotates lever A about pin C so as to raise it out of the rocket groove.

**Suggested by:** R. F. MALLINA

MODEL #17Loading from Front End

Lever A rotates about pin B elongating spring C. Due to slope F it moves forward as it rotates.

Loading from Rear End

Same as "Loading from Front End".

Firing - Rocket Moving Forward

Lever A moves forward horizontally until the slope D on lever A reaches pin E after which the lever A is rotated about the pin B.

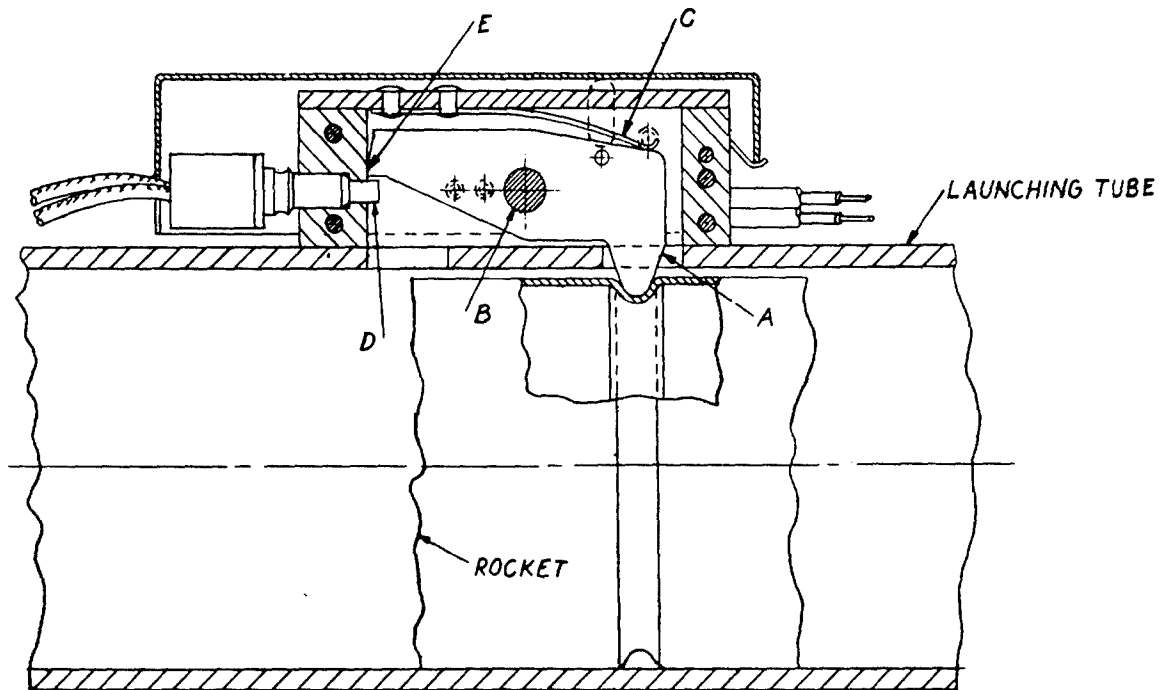
Firing - Rockets moving Rearward

Lever A tends to move rearward horizontally but due to slope F it will dig in tighter.

Igniter

A jack will be provided for the plug on the rocket.

Suggested by: W. H. SCHWEYHER



#### MODEL #18

##### Loading from Front End

Latching lever A rotates about pin B compressing spring C. When rocket is latched in place, the ignition plug is inserted and the tip D of the plug locks the lever A in place.

##### Loading from Rear End

Same as "Loading from Front End".

##### Firing - Rocket Moving Forward

Latching lever A rotates counter clockwise about pin B shearing tip D on ignition plug by means of cutting edge E on lever A.

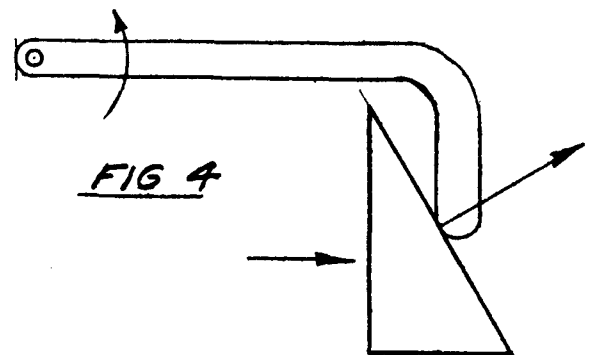
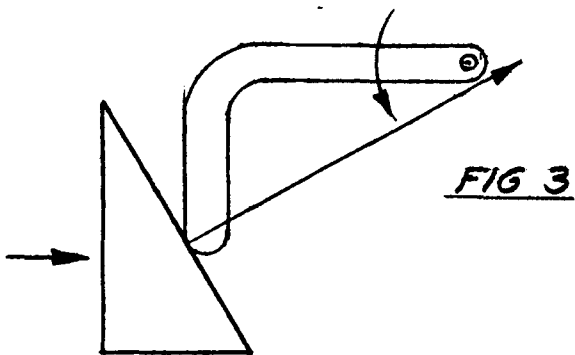
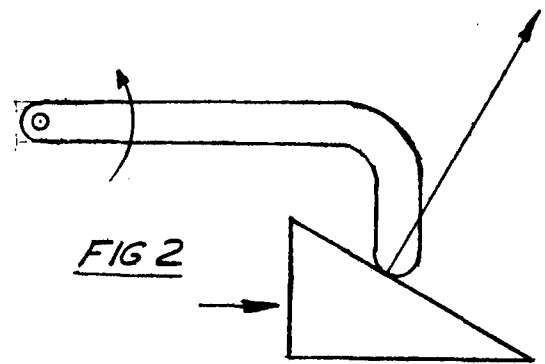
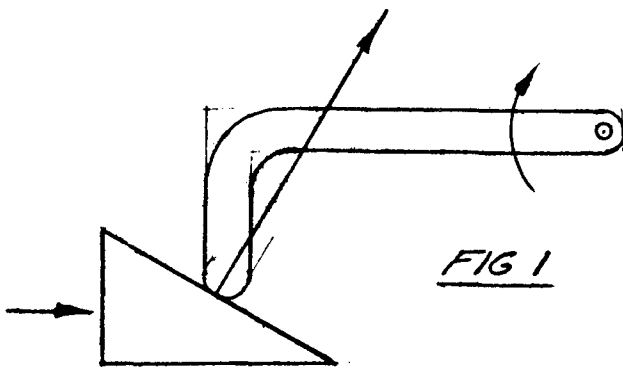
##### Firing - Rocket Moving Rearward

Latching lever A tries to rotate in a clockwise direction but wedges holding rocket.

##### Ignition

The frame of the latch and a contact spring (not shown) make contact with the ignition plug.

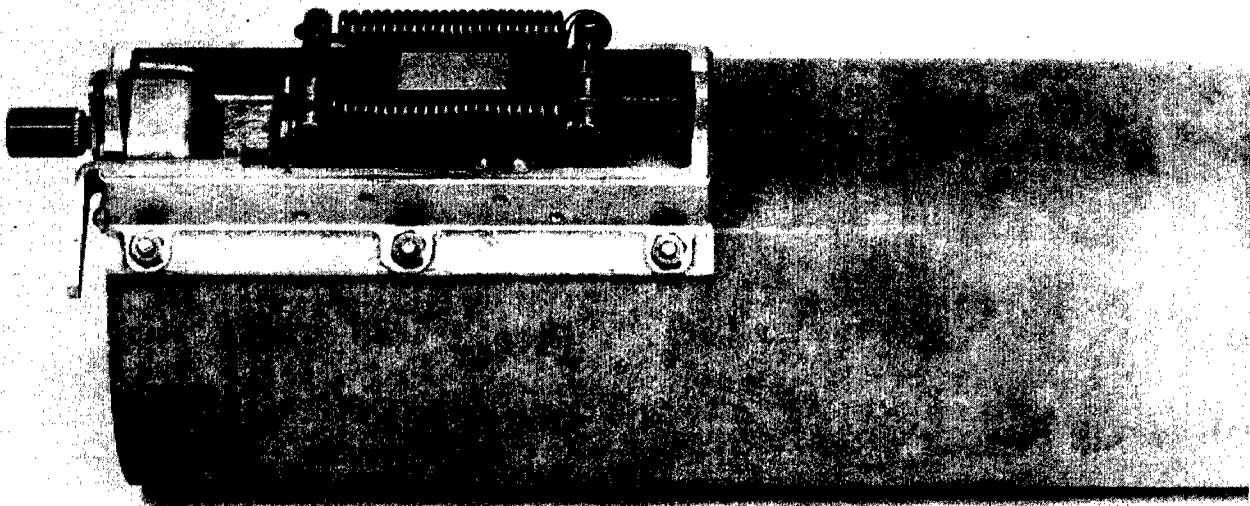
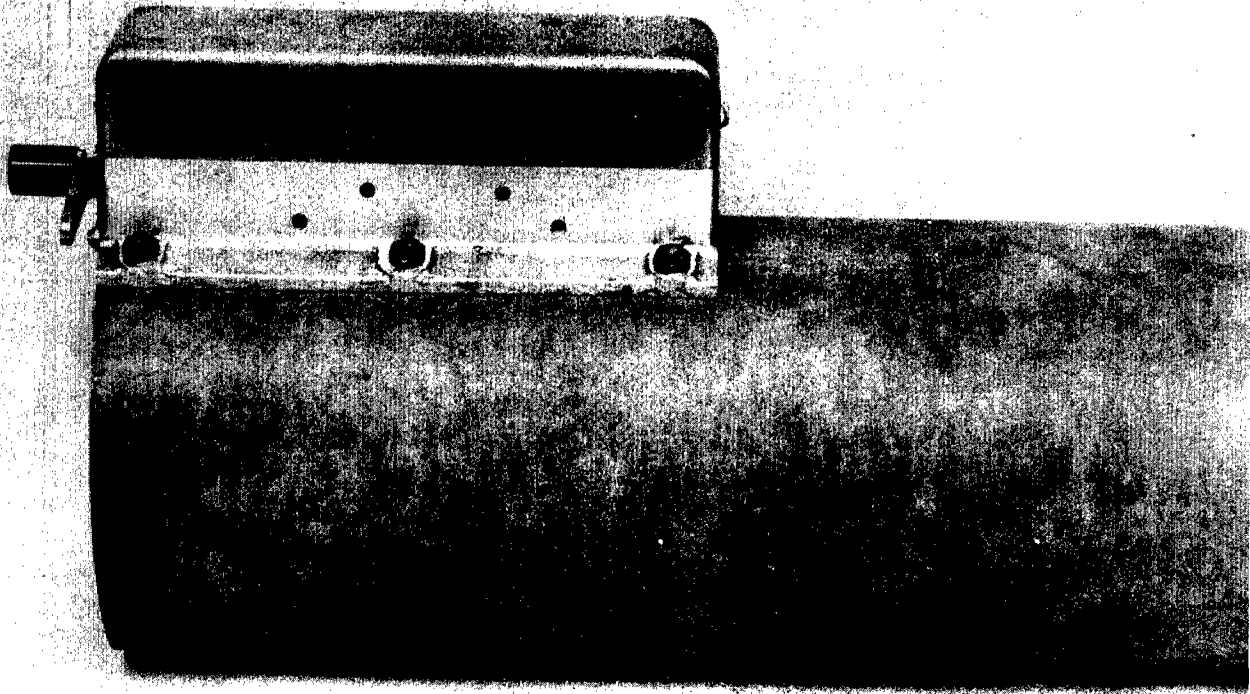
## FORCE DIAGRAM





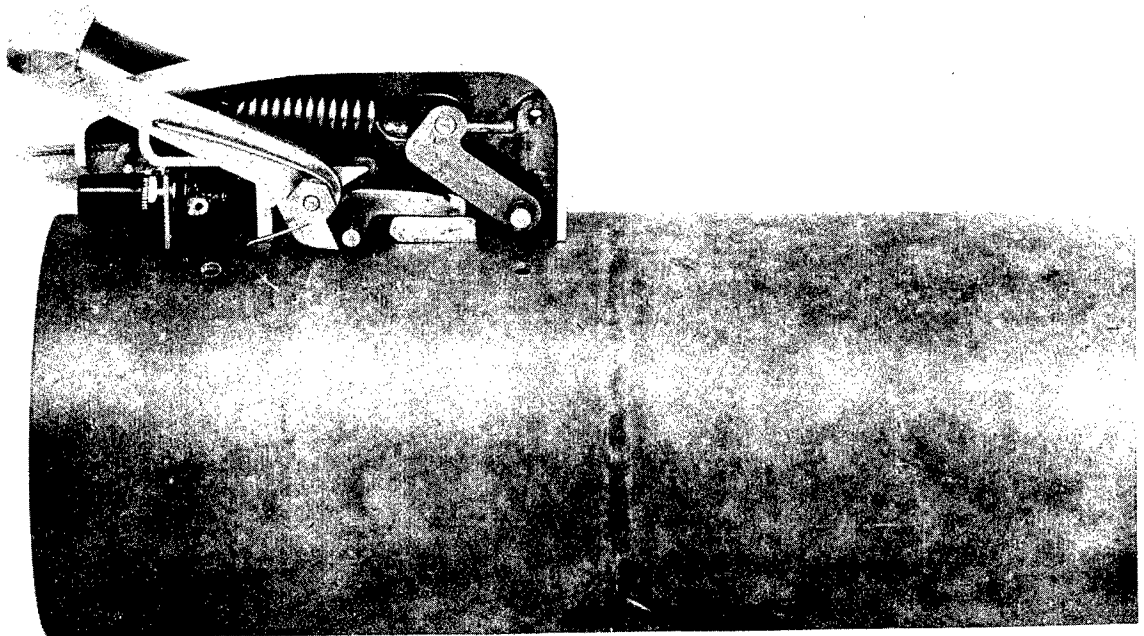
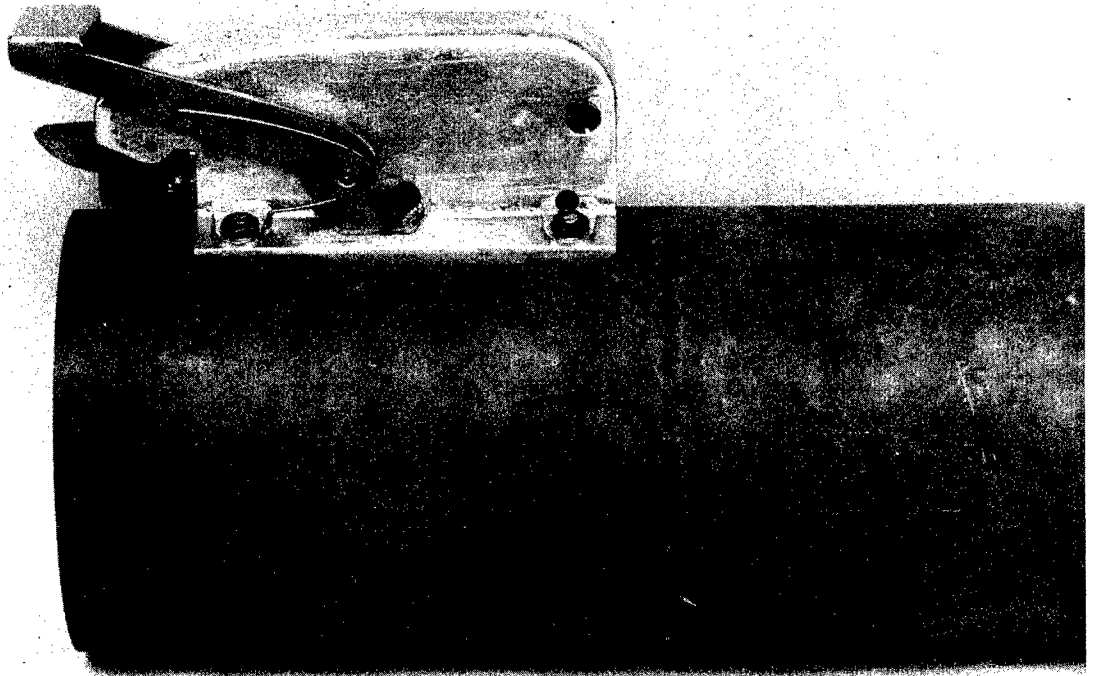






121810

HOLDING DEVICE MODEL 11



121811

HOLDING DEVICE MODEL 15

Rating of Various Models with Respect to  
Their Features

TABLE I

Model No.	Point of Rocket Engagement	Loading		Release Rearward on Parting	"Dig In" Characteristic		Cushioning		"Overshooting" in Loading		Effect on Release of Angle of Engagement Surface of Rocket	Quick Release
		From Front	From Rear		Forw.	Rear.	Forw.	Rear.	From Front	From Rear		
1	Pin Flange	Yes	Yes	No	No	Yes	No	No	Yes	Yes	Critical	No
2	" "	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Not critical	Yes
3	" "	Yes	Yes	Yes	No	No	Yes	Yes	No	No	Critical	No
4	" "	Yes	Yes	Yes	Part.	Part.	Part.	Part.	No	No	Critical	Yes
5	Grooves	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Not critical	Yes
6	Grooves	No	Yes	Yes	No	No	No	Yes	-	Yes	Critical	No
7	Pin Flange	Yes	Yes	Yes	Part.	Part.	Part.	Part.	No	No	Critical	Yes
8	Front & Rear	Yes	Yes	Yes	No	No	No	No	No	No	Not critical	No
9	Groove	Yes	Yes	Yes	No	No	Yes	Yes	No	No	Critical	No
10	Groove	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Not critical	Yes
11	Groove	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Not critical	Yes
12	Groove	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Not critical	Yes
13	Groove	Yes	Yes	Yes	No	No	Part.	Part.	Yes	Yes	Critical	No
14	Groove	Yes	Yes	Yes	No	No	Part.	Part.	Yes	Yes	Critical	No
15	Groove	Yes	Yes	Yes	No	No	Yes	Yes	No	No	Critical	No
16	Groove	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	Not critical	Yes
17	Groove	Yes	Yes	No	No	Yes	No	No	Yes	Yes	Critical	No
18	Groove	Yes	Yes	No	Yes	No	Yes	No	No	No	Not critical	Yes
					No	Yes	No	No	No	Yes	Not critical	Yes

Notes

See Engineering Considerations Page

PART VII  
CONTROL VALVE

INTRODUCTION

In June 1943, Section H of the NDRC requested the Bell Telephone Laboratories to consider means for preventing the propellant gas pressure of a rocket from reaching a value which might cause bursting of the rocket. The pressure developed in a rocket increases with an increase in the ambient temperature and if a rocket is loaded for a cold climate and used in a hot climate without removing some of the propellant powder there will be danger of it bursting. Conversely if it is loaded for use in a hot climate, there will not be sufficient powder for firing at a low temperature. It was therefore desirable to have a rocket equipped with a pressure regulating device that would permit its use in any climate.

DESCRIPTION

The variation of rocket pressure with temperature is shown in sketch, ES-579252, Page 171. Since the pressure is dependent on the throat area, it was decided to regulate the pressure by having a variable throat orifice in the rocket. One of the first devices considered was one in which the throat opening could be adjusted by means of a thermostatic control. This was not developed as it was decided that it would be somewhat complicated and difficult to streamline. An arrangement in which the throat could be adjusted manually by turning a

dial at the rear of the rocket is shown in sketches ES-579239 and ES-579240, Pages 172 and 173. The dial could be set for the temperature at which the rocket was to be fired. This design had the disadvantage of requiring an extra operation so it was proposed to consider devices that would automatically control the throat area by the pressure within the rocket. A design in which rings of various sizes on a shaft would be sheared off by the pressure on bulb or valve is shown in sketch ES-579241, Page 174, and a similar arrangement with pins instead of rings is shown in sketch ES-579242, Page 175. Neither of these designs was built as it was felt that once the first ring or pin was sheared, the kinetic energy of the valve would carry it along and shear the remaining rings. Another valve in which the pressure of the gas is used to cut metal is shown in sketch ES-579250, Page 176. The cutting tool consists of a hardened ring which is inserted in the valve. The valve is placed on a steel pinion rod that is threaded at one end and screwed into a cast iron spider which fits against the throat of the rocket. As the valve moves, the cutting tool shaves off the upper portion of the teeth on the pinion rod. The metal comes off in curled chips as shown by photographs of the two test samples on Page 176, below the sketch. A number of samples of steel pinion rod were tested in order to determine the force required to do the shearing. The results of these tests are plotted on graph BA-290891, Page 169, and show that the force is approximately proportional to the area of the material removed. The area

is taken as the product of the number of teeth, tooth thickness at the cutter and the depth of the chip. Several valves of this type were built and while they performed satisfactorily it was suggested that if instead of the shearing action a wire drawing action were used a simplified design would result. A valve embodying this principal is shown in sketch ES-579249, Page 177. The wire drawing tool is part of a hardened steel valve 1, and it reduces the diameter of an annealed cold rolled steel rod 3, as it moves from M to N. The force required to draw annealed rods of various diameters through a .314 diameter die are shown in graph BA-290892, Page 170, which shows that the force is proportional to the reduction in diameter. About 50 of these valves were made in accordance with drawings ES-579232, ES-579233, and ES-579234, Pages 178 to 180, incl., and tested at the NDRC Jet Propulsion Research Laboratory; Indian Head, Md. The results of some of these tests are listed on Page 181, and photographs of the valves after firing together with pressure time oscillographs are shown in plate ES-579246, Page 182.

#### CONCLUSIONS

The results of the above tests indicated that the valve would permit the use of a rocket in temperatures from -50° to +130°F. In order to have an increasing resisting force as the valve moves along the rod a taper from .317" diameter to .328" diameter was recommended. The NDRC placed an order for 25,000 valves with the Bardco Mfg. and Sales Co., Los Angeles,



California and the Bell Telephone Laboratories cooperated with them in furnishing information for the fabrication of the parts.

Due to the adoption of an improved propellant, which was not so critical to pressure, the valve was not used by the services.

PART VIILIST OF ILLUSTRATIONS

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BA-290891      Shearing Cutter Curve	169
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ES-579250      Pinion Rod Shearing Type Control Valve (Photo.110797)	176
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ES-579232      Nozzle Adjustment Spider	178
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Table -          Control Valve Data	181
ES-579246      Pressure Time Oscillographs for Control Valves	182

BIBLIOGRAPHY

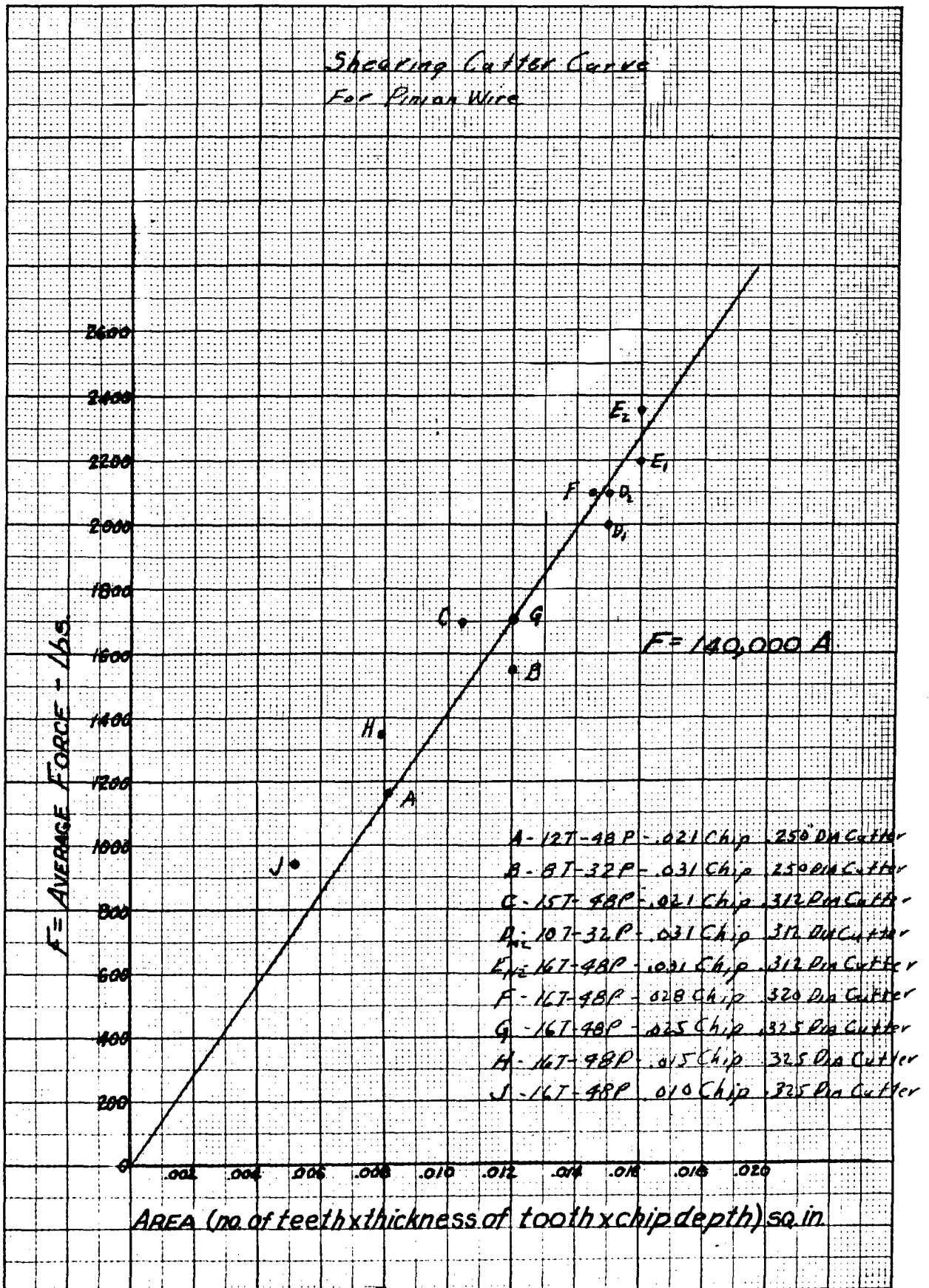
September 2, 1943, Memo for File by R. F. Mallina on Control Valve of 4-1/2" Projectile.

September 3, 1943, Report by Alfred Africano on Pressure Control Valves for the 4-1/2" Rocket.

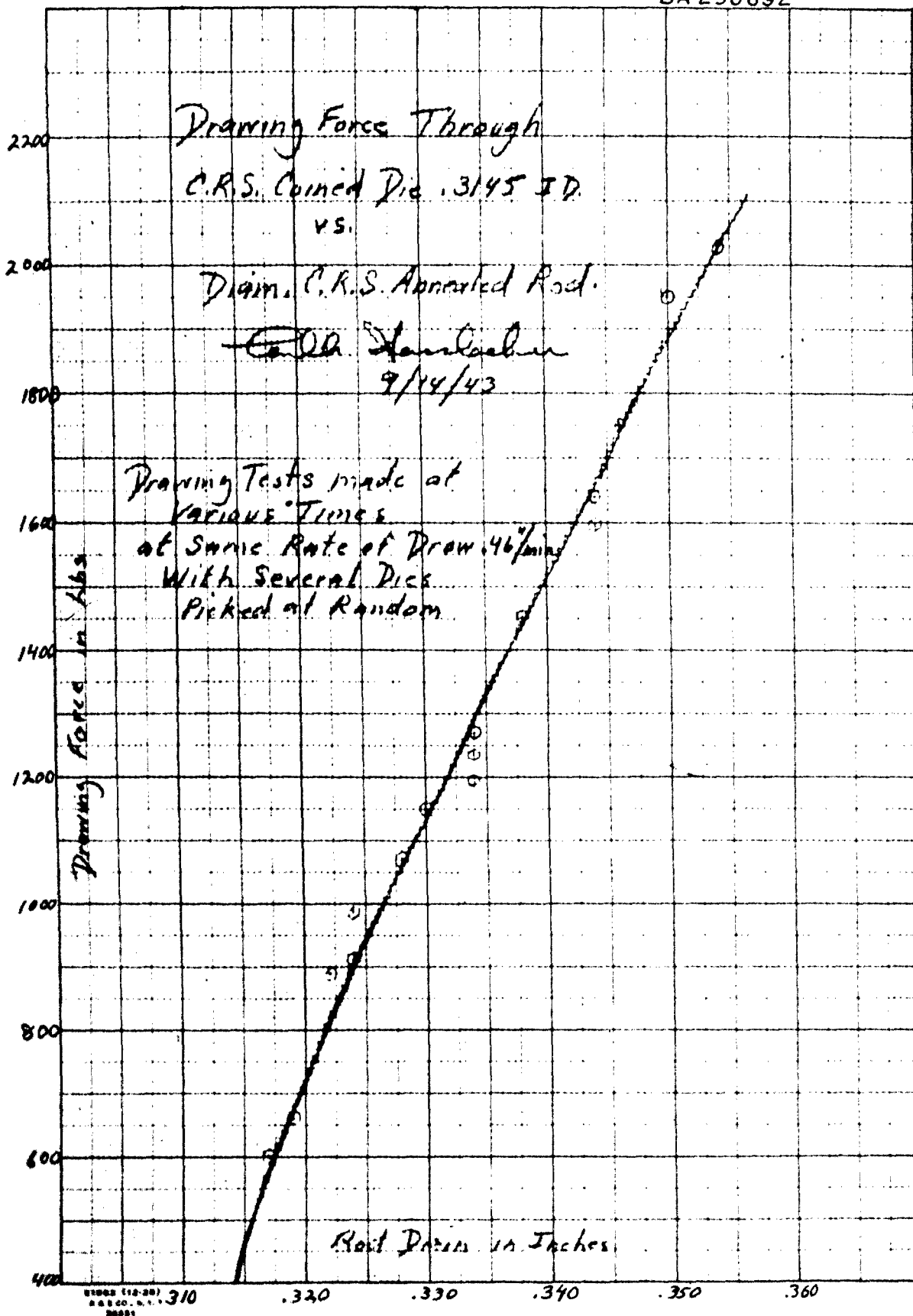
September 4, 1943, Report by Alfred Africano on Pressure Control Valves for the 4-1/2" Rocket.

September 14, 1943, Memo for File by F. G. Foster on Examination of Cast Iron Spider of Control Valve for 4-1/2" Rocket.

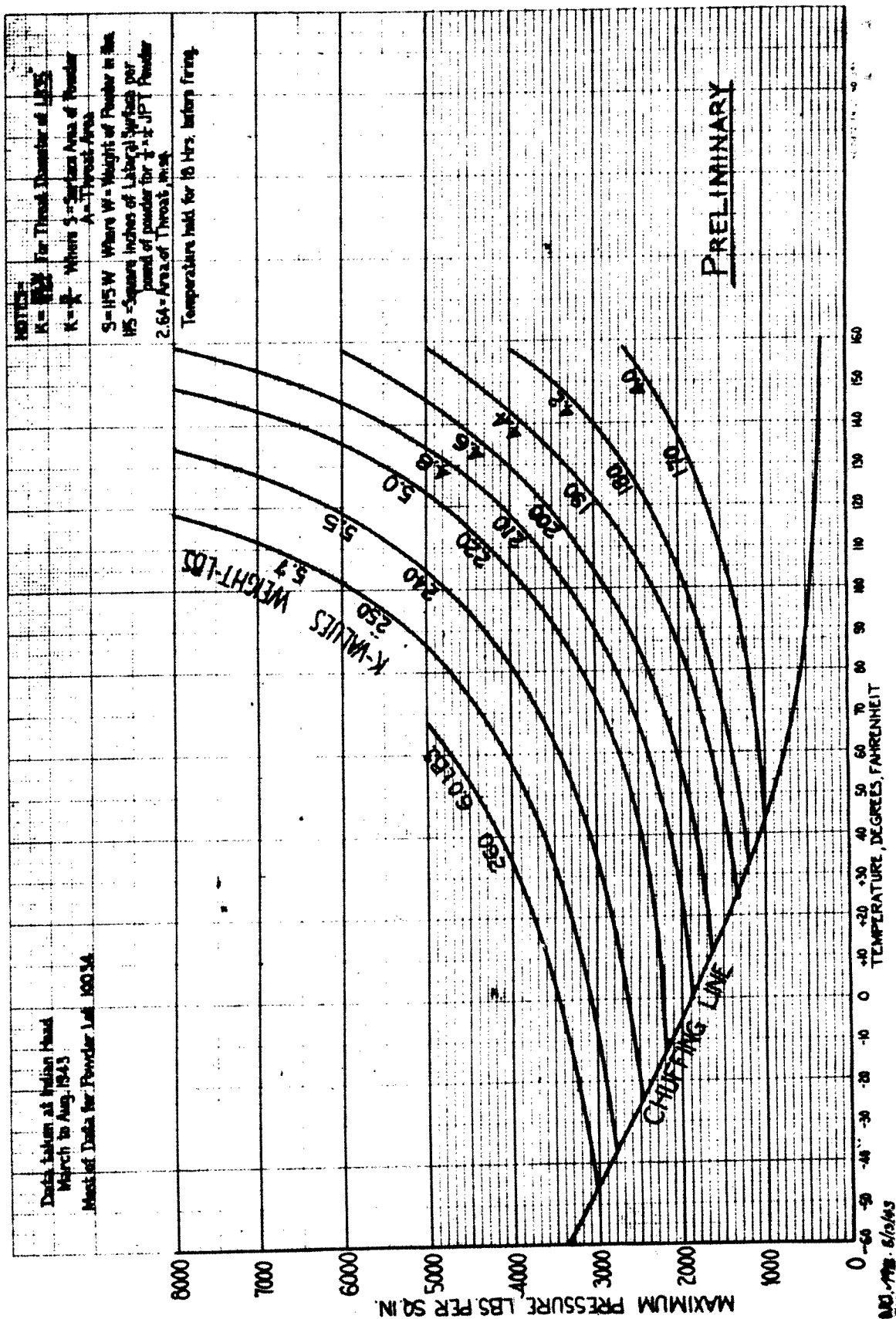
September 11, 1943, Report by D. W. Osborne and M. J. Walker on Flight Test of 4-1/2" Rockets with Control Valves.



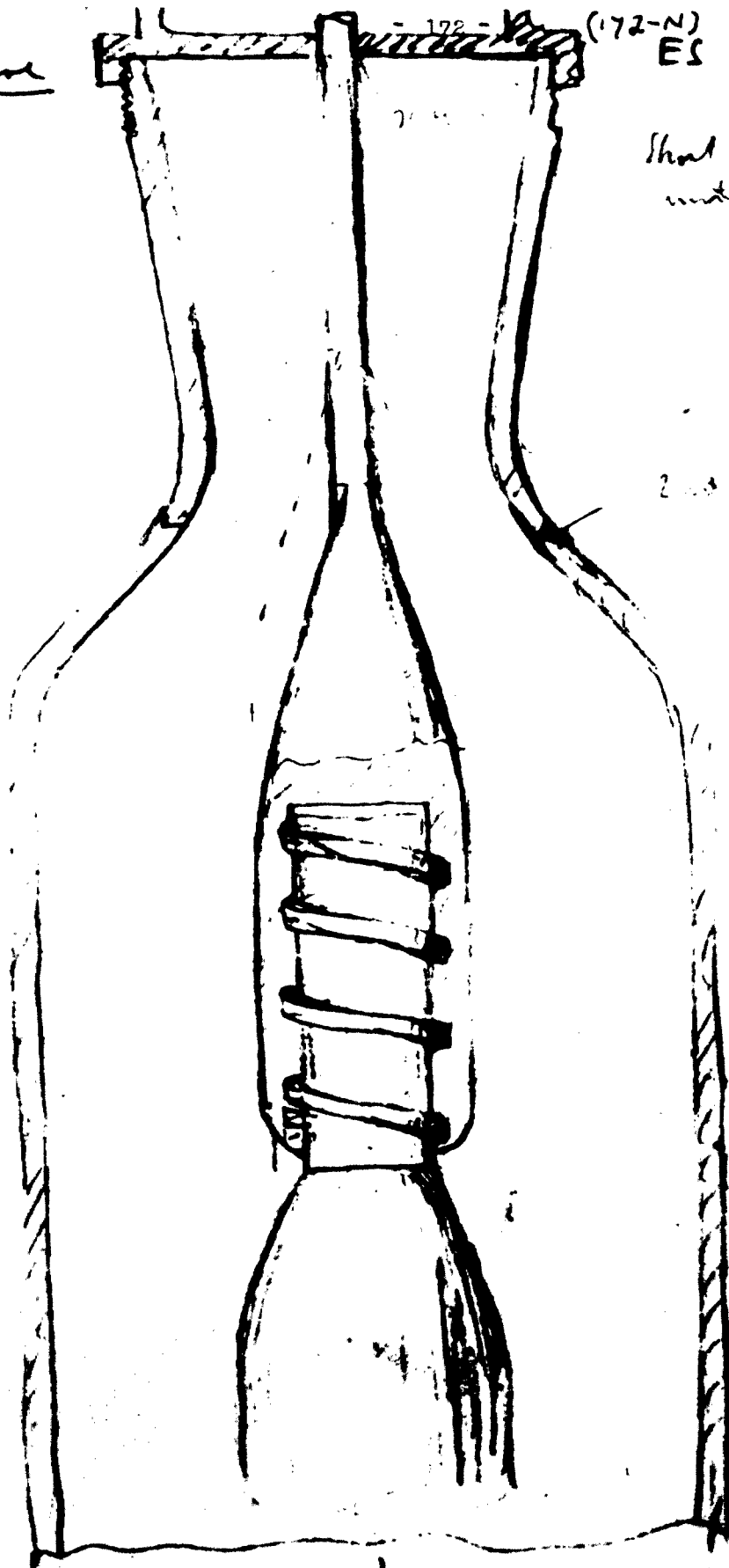
BA 290892



ES-579252



Control Valve



(172-N)

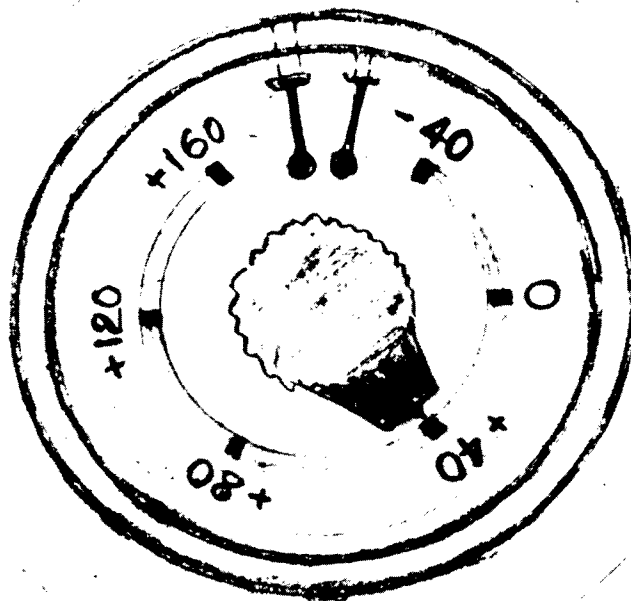
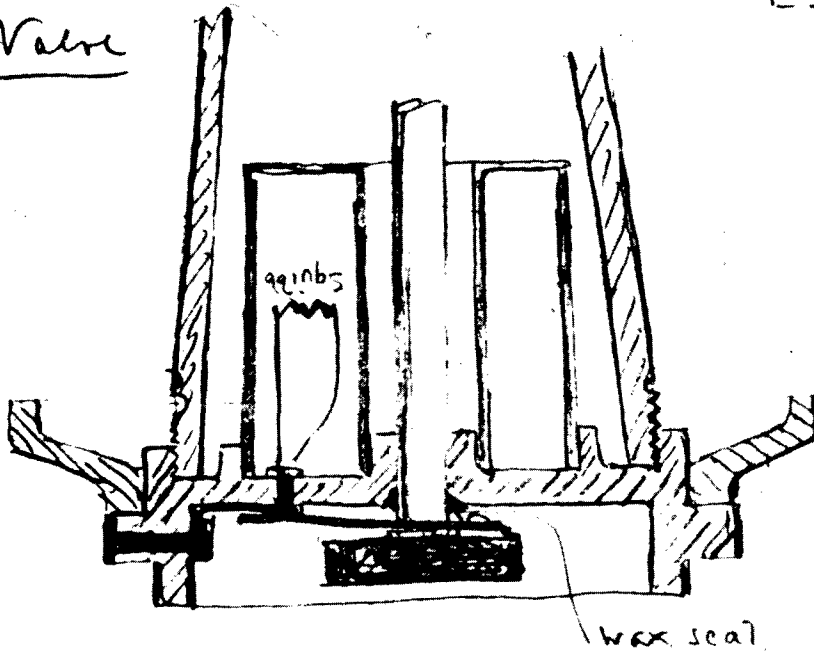
ES 579 239

Shut circuit  
until adjusted

2nd 1/2

6/10/43

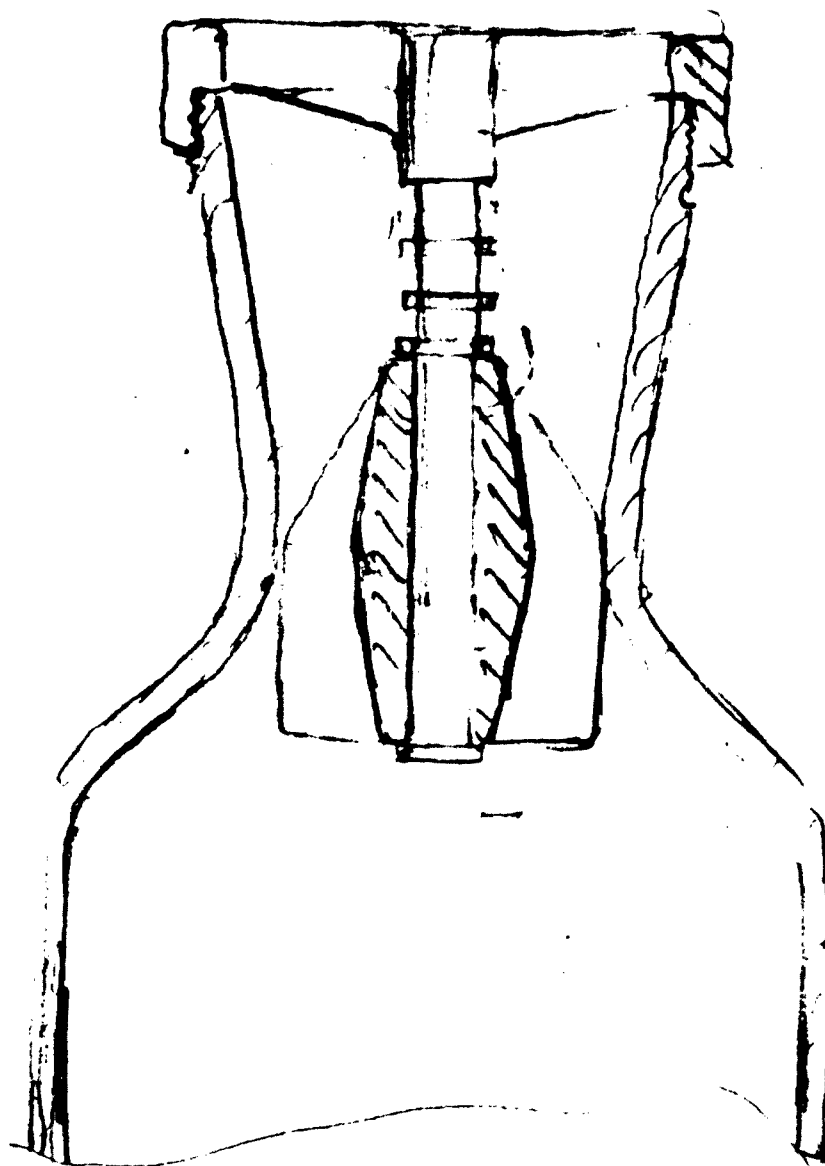
ES-579240

Control Valve

6/12/43



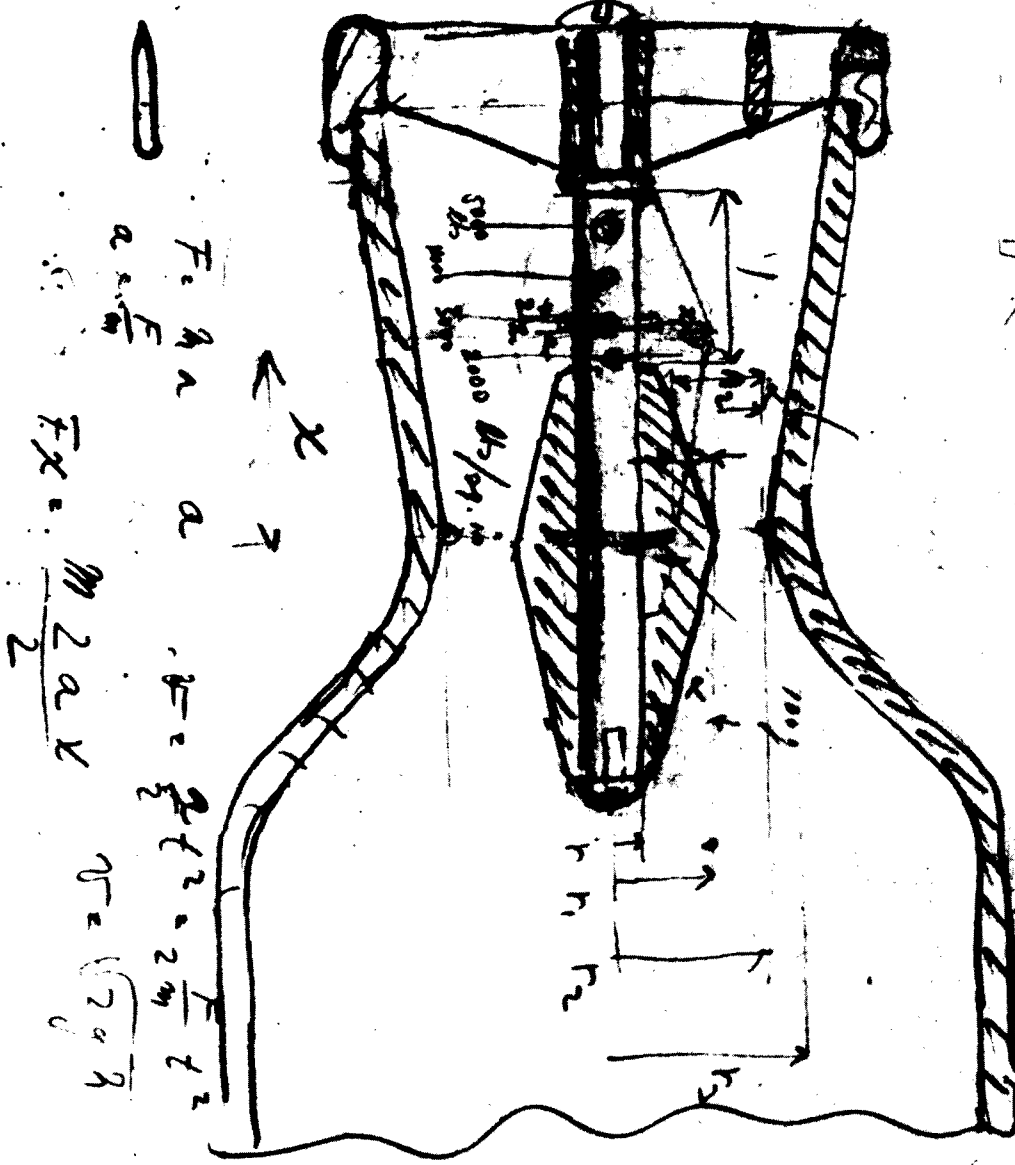
ES - 579 241

Artificial Valve

6/22/80

Control Valve

ES-579242



$$F = A p$$

$$a = \frac{F}{A}$$

$$F x = \frac{M}{2} a x$$

$$r = \sqrt{\frac{2 a x}{g}}$$

$$v = a x$$

$$F = A p$$

$$A = \pi r^2 - r_1^2$$

$$r_1^2 = 1.25 r_2^2$$

6/23/43

ES-579250

Control Valve and Ignition Plug  
of 4 1/2" Reverse Projectile

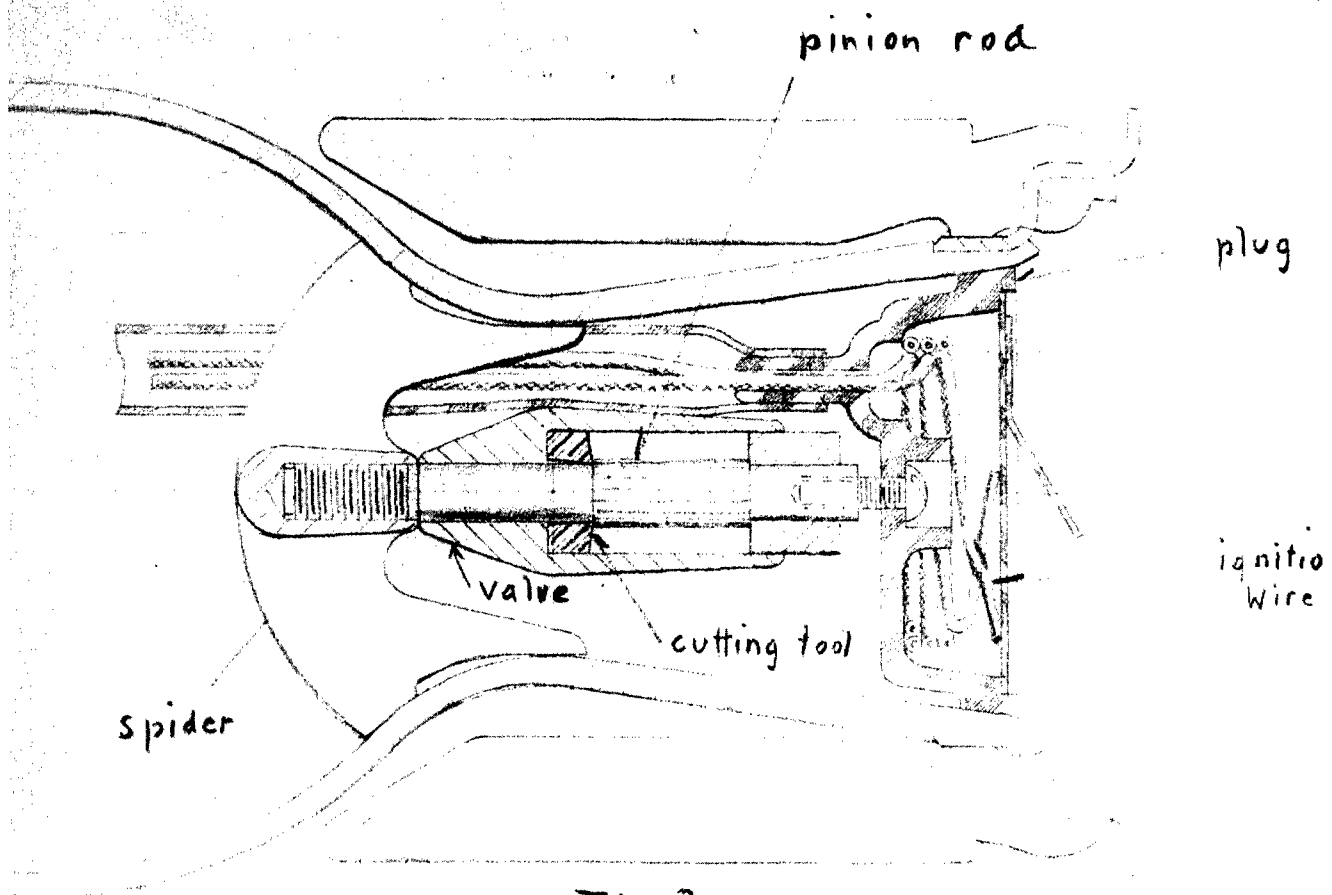


Fig. 3



110797

PINION ROD SHEARING TYPE CONTROL VALVE

ES - 579249

Control Valve and Ignition Plug  
of 4 1/2" Reverse Projectile

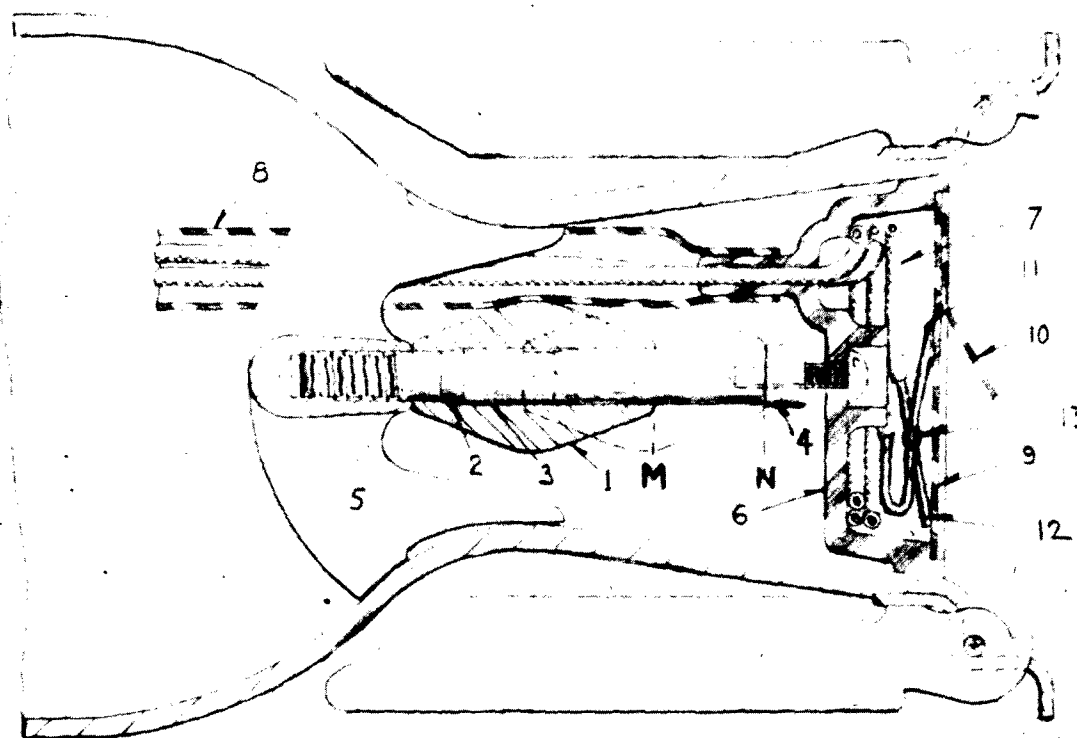
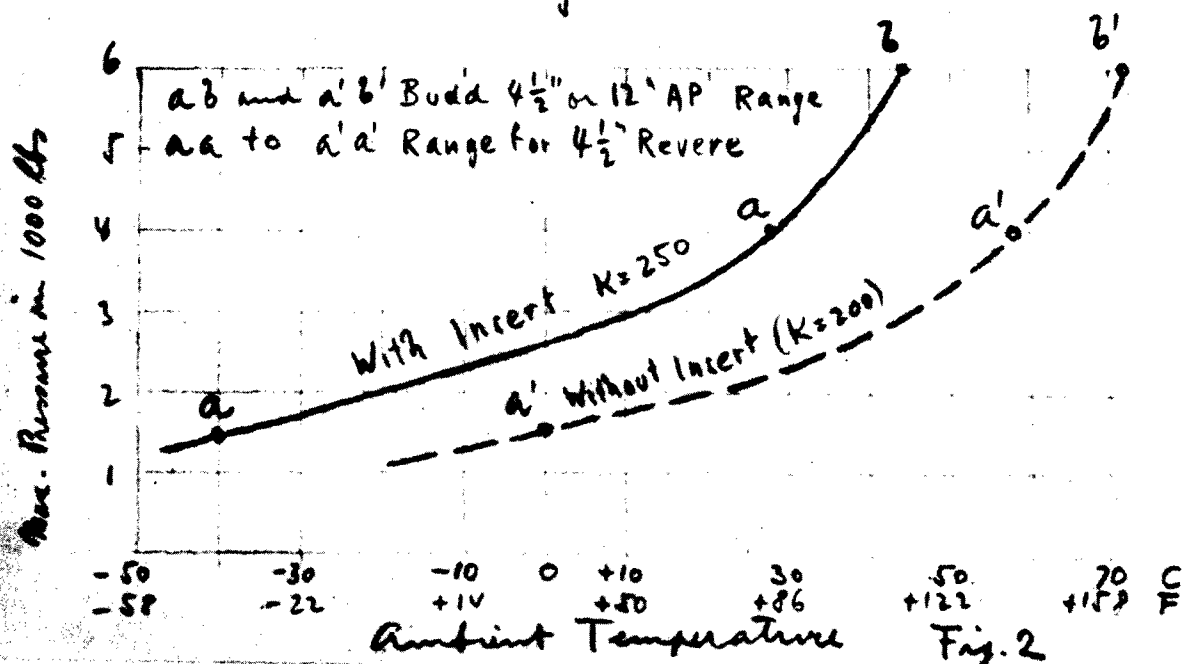
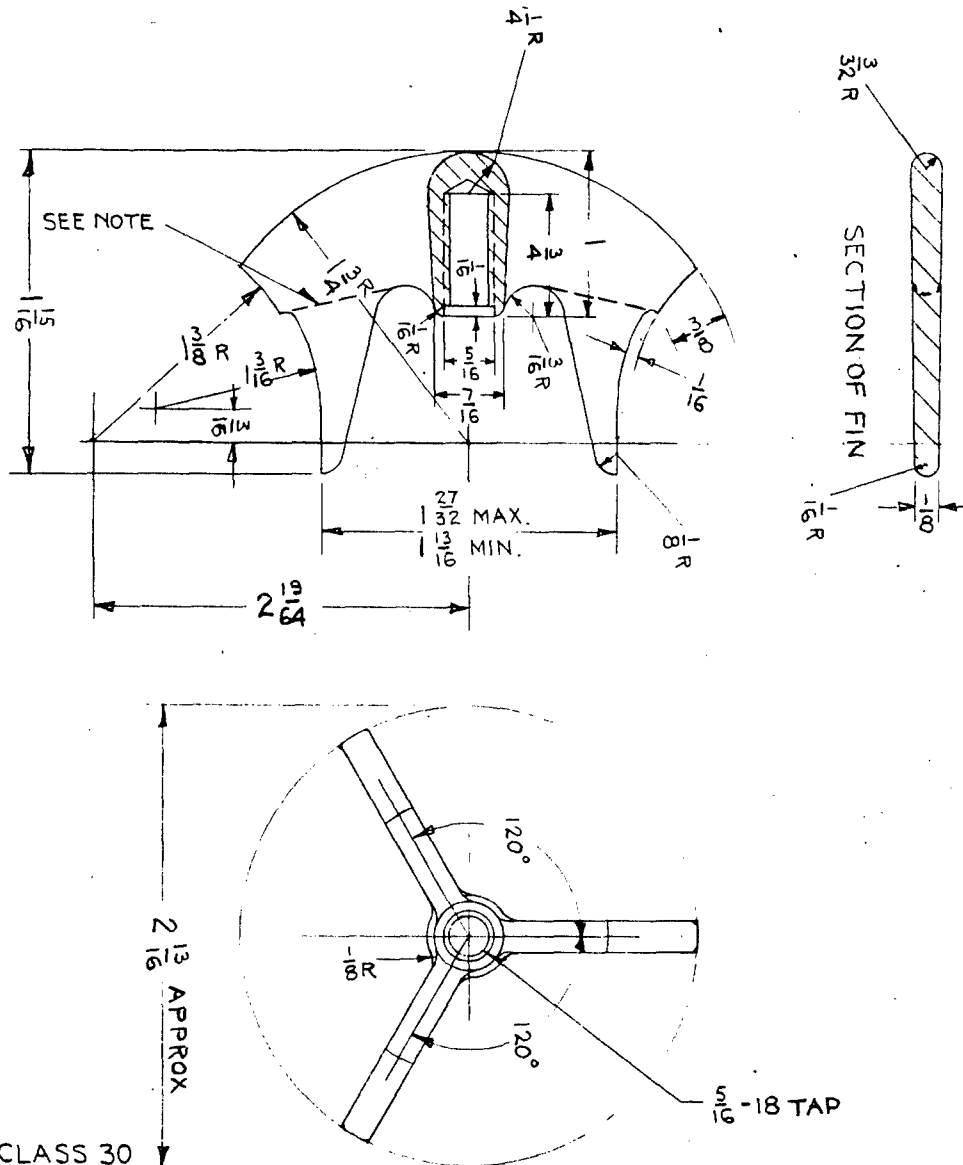


Fig. 1



## NOTE

FOR DET-2, WORK TO DOTTED  
LINE, OTHERWISE SAME AS DET-1



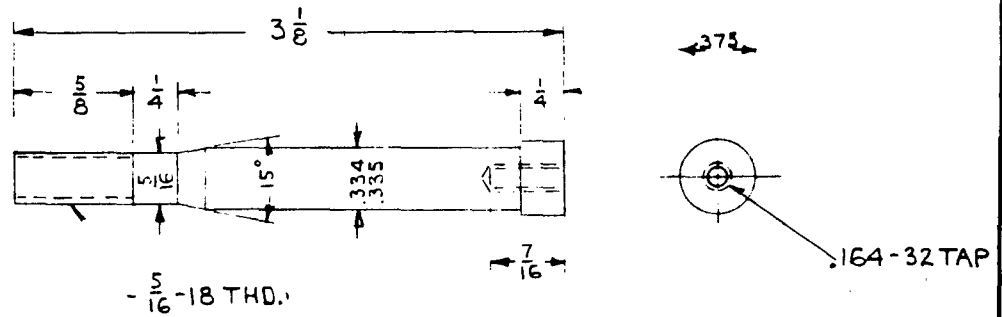
ASTM A 48 CLASS 30  
NAVY SPEC 4615 CLASS A  
ANNEAL 900°F TO 950°F  
FOR 1-HOUR  
HEATING RATE 300°/HR

DET 1 & DET 2 (SEE NOTE)

ISSUE 1 8-5-43  
ISSUE 2 8-10-43  
ISSUE 3 8-12-43

DR. JAH  
CH. ENG. CFS  
APPL.

TITLE  
NOZZLE  
ADJUSTMENT  
SPIDER  
SCALE 1/1  
BELL TELEPHONE LABORATORIES, INC., NEW YORK  
ES 579232



STEEL (C.R.)  
ANNEALED ROCKWELL B60 TO B65

ISSUE 1 8-7-43

ISSUE 2 8-12-43

DR. JAH

APPL.

CH.

ENG. CFS

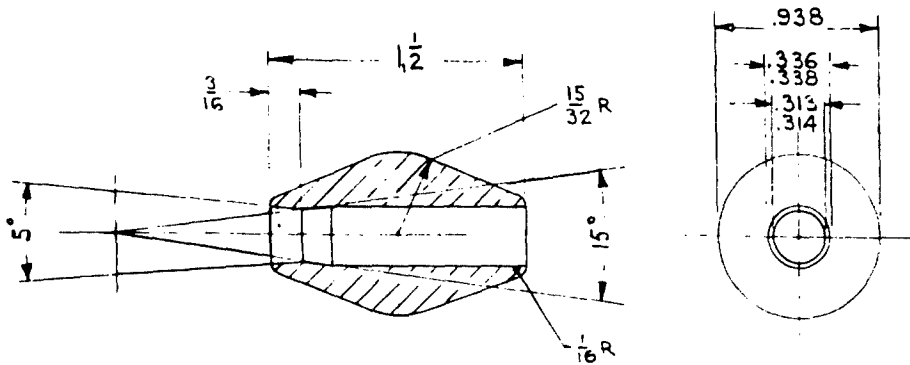
TITLE

NOZZLE  
ADJUSTMENT  
SHAFT

SCALE 1/1

BELL TELEPHONE LABORATORIES, INC., NEW YORK

ES-579233



C.R. STEEL CASE HARDENED  
ROCKWELL 45 N 65 MIN.

ISSUE 1 8-11-43

DR. JAH  
ENR. CES  
APPL.

TITLE  
NOZZLE  
ADJUSTMENT  
DRAW DIE  
SCALE 1:1  
BELL TELEPHONE LABORATORIES, INC., NEW YORK  
ES-579234

Y

CONTROL VALVE DATA

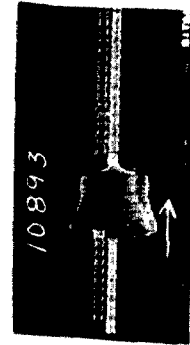
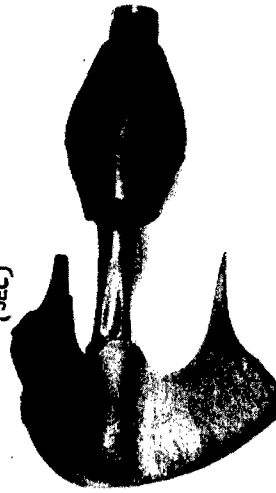
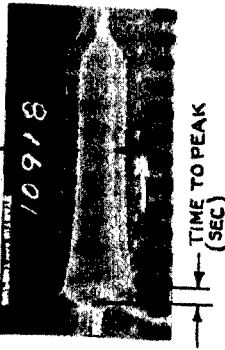
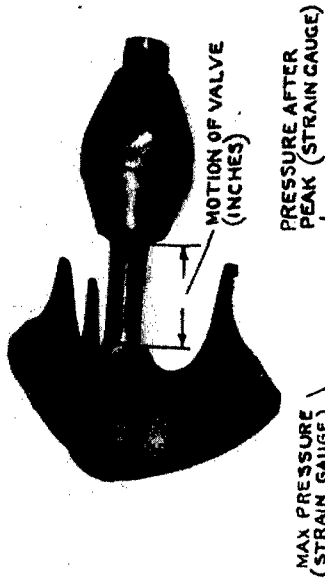
<u>Valve No.</u>	1	2	3	4	5	5a	6
						.	..
Round No.	10897	10898	10813	10883	10984	10840	10893
Weight Charge Lbs.	3.60	4.00	4.20	4.60	4.60	4.60	4.60
K <sub>1</sub>	218	244	255	279	282	283	208
K <sub>2</sub>	215	222	191	203	203	203	208
Max. Press Cu	2400	3200	2900	4150	4125	4300	3200
Max. Press Strain gage	2200	3200	2860	3960	3760	4400	3300
Press after Peak Strain gage	1900	2400	1900	2500	2640	2640	2300
Estimated Peak Pressures for No valve motion	2700	3700	4700	8000	9000	9000	2700
The valve "	2700	3300	3000	2700	2700	2700	3700
Time to peak sec.	.014	.032	.013	.012	--	.003	.033
Motion of valve inches	0	.10	.75	.75	.75	.75	0
Diameter of Draw Rod							
Before draw	.333	.333	.325	.353	.333	.334	.320
After draw	.320	.320	.320	.320	.320	.314	.320
Wt. Spiner and Valve							
Before firing	190.3	192.0	194.0	--	190.3	190.0	189.0
After firing	171.0	181.0	170.0	--	181.5	188.0	188.0
Change in wt.	19.3	11.0	24.0	--	8.8	2.0	1.0
Static force to draw lbs.	900	900	900	900	900	1100	--

\*Note greater drawing force

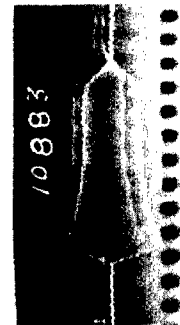
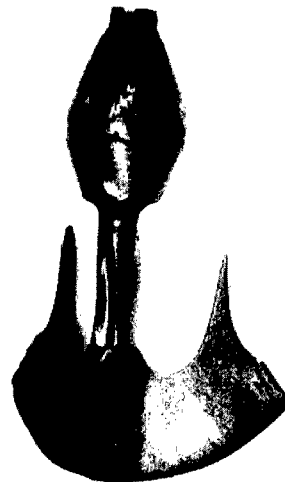
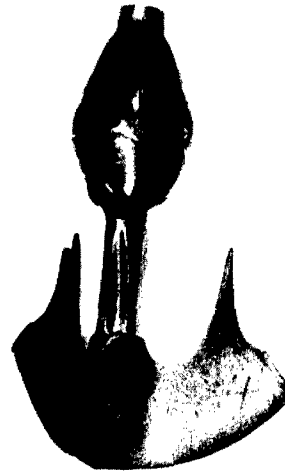
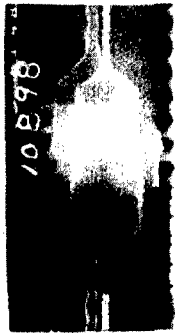
\*\*No draw, valve at rear at time of firing



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 Mallina, R. F.  
 Spahn, C. F.  
 and others

DIVISION: Ordnance and Armament (22)

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## ABSTRACT

Light weight ground launcher, jungle launcher, and rotating projector were developed for 4.5" rocket. Rotating projector was developed for purpose of studying effect of rotation of rocket on its dispersion. Improvements of rocket components consisted of a redesign of tail end for purpose of coordinating parts which will effect ignition system and development of an igniter which may be inserted through nozzle. Eighteen devices for holding rockets in launching tube and a pressure regulating device that would permit use of rocket in any climate were also developed.

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T-2, HQ., AIR MATERIEL COMMAND

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